

Institutional Drivers of Green Skills Development in Ghanaian Higher Education

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Abstract

Universities are increasingly expected to develop green skills that support sustainable development and the transition to low-carbon economies. However, empirical evidence explaining how institutional conditions within higher education shape students' environmental knowledge and pro-environmental behaviour remains limited, particularly in Sub-Saharan Africa. This study investigates the institutional pathways through which green skills develop among university students, using evidence from a public university in Ghana. Anchored in Human Capital Theory and Institutional Theory, and informed by behavioural perspectives, the study proposes and tests a structural model linking University Initiatives and Support for Green Skills Development, University Curriculum and Green Skills Integration, and University Environment and Culture to students' Knowledge of Environmental Processes and Behavioural Intentions and Practices. Data were collected from 353 undergraduate students using a validated Green Skills Competency Questionnaire and analysed using partial least squares structural equation modelling (PLS-SEM). The results show that institutional initiatives significantly predict curriculum integration ($\beta > 0$, $p < 0.05$) and university environment and culture ($\beta > 0$, $p < 0.05$), while both curriculum integration and campus environment are positively associated with students' environmental knowledge ($p < 0.05$). Environmental knowledge is significantly related to behavioural intentions and practices, and the model explains a substantial proportion of variance in knowledge and behaviour. The findings indicate that green skills development in higher education occurs through interconnected institutional, curricular, and environmental processes rather than curriculum exposure alone, and provide policy-relevant insights for strengthening green skills development in Ghana and comparable Sub-Saharan African contexts.

KEYWORDS: Green skills development; Higher education; Institutional drivers; Sustainability education; Pro-environmental behaviour; University students; Ghana

1. Introduction

The accelerating global transition toward sustainable development has reshaped expectations of what it means for university graduates to be work-ready (OECD, 2022; UNESCO, 2017). Across economies, responding effectively to climate change, resource scarcity, and ecological degradation increasingly requires the development of green skills, broadly understood as a combination of environmental knowledge, technical competence, problem-solving ability, and pro-environmental values that enable individuals to contribute to low-carbon and resource-efficient systems (Wiek et al., 2011; OECD, 2022). Within this context, higher education institutions (HEIs) are no longer viewed only as producers of knowledge, but also as key actors in preparing graduates with the competencies required for sustainable development and green economic transition (Cortese, 2003; Lozano et al., 2017).

Despite these growing expectations, a persistent challenge continues to appear in both policy discussions and empirical research. Many university graduates demonstrate awareness of environmental problems and express positive attitudes toward sustainability, yet far fewer seem to possess the applied competencies, institutional exposure, and supportive conditions needed to translate this awareness into consistent practice or professional readiness in green-related fields (Kollmuss & Agyeman, 2002; Lambrechts et al., 2013). This gap between knowledge, intention, and practice has been widely discussed in the sustainability education literature, particularly in settings where institutional support structures and experiential learning opportunities are limited (Bamberg & Möser, 2007; Sterling, 2010). These observations suggest that the effectiveness of sustainability education may depend not only on what is taught in the curriculum, but also on the broader institutional environment in which learning takes place.

These concerns are especially relevant in Sub-Saharan Africa (SSA). Universities across the region have increasingly incorporated sustainability into strategic plans, introduced environmental courses, and supported student-led initiatives (Tilbury, 2011; Leal Filho et al., 2018). However, the extent to which sustainability principles are fully integrated across curricula, campus practices, and institutional systems often remains uneven (Lozano et al., 2015). As a result, sustainability education in many SSA contexts can appear fragmented and weakly connected to measurable student outcomes or labour-market needs (UNESCO, 2017). What remains insufficiently explored is how different institutional conditions work together to shape students' environmental knowledge and behavioural orientation within higher education settings (Wiek et al., 2011; Leal Filho et al., 2018).

Ghanaian higher education provides a particularly relevant context in which to examine these dynamics. Universities in Ghana have made visible efforts toward environmental engagement, including the introduction of sustainability-related programmes, student organisations, and campus greening activities (Tilbury, 2011; UNESCO, 2017). However, empirical studies that systematically analyse how curriculum design, campus environment and culture, and institutional initiatives jointly influence student-level outcomes remain limited (Lozano et al., 2015; Sterling, 2010). Much of the existing literature is descriptive, offering little model-based evidence on the institutional pathways through which sustainability knowledge and

behavioural intentions develop among students (Lambrechts et al., 2013; Barth & Rieckmann, 2016). Consequently, policy and institutional reforms are often guided more by assumptions than by empirical evidence (Cortese, 2003).

This study addresses this gap by proposing and empirically testing a structural model of green skills development in higher education. Specifically, the study examines how University Initiatives and Support for Green Skills Development (UISGSD), University Curriculum and Green Skills Integration (UCGSI), and University Environment and Culture (UEC) relate to students' Knowledge of Environmental Processes (KEP) and their Behavioural Intentions and Practices (BIP). By considering these relationships simultaneously, the study responds to calls for institution-level analyses that recognise governance, curriculum, and campus context as interconnected influences on sustainability education outcomes (Wiek et al., 2011; Lozano et al., 2017). In doing so, the study moves beyond surface-level descriptions of sustainability education to examine the institutional mechanisms through which environmental knowledge and behavioural orientation are formed (Sterling, 2010).

The model is conceptually informed by Human Capital Theory, which views education as a process that enhances individual capabilities (Becker, 1993), and Institutional Theory, which emphasises the role of organisational structures, norms, and supports in shaping behaviour within social systems (Scott, 2014). Insights from behavioural research, including the logic associated with the Theory of Planned Behavior (Ajzen, 1991), further suggest that knowledge and contextual conditions may influence behavioural intentions, although the present study does not directly measure all classical TPB constructs. Taken together, these perspectives support an institutional pathway approach in which student outcomes are shaped by the interaction of curriculum, institutional environment, and organisational support. This interpretation is consistent with previous work showing that the development of sustainability-related competencies depends not only on individual learning but also on institutional arrangements that enable the acquisition and application of human capital (Dankyi, 2020).

Guided by this framework, the study addresses the following research questions:

1. How do curriculum integration, campus environment and culture, and institutional support mechanisms relate to students' environmental knowledge and behavioural intentions and practices?
2. What policy-relevant insights emerge for universities and policymakers seeking to strengthen green skills development in Ghana and comparable Sub-Saharan African contexts?

By addressing these questions, the study contributes to the sustainability education literature in three ways. First, it provides a theoretically informed and empirically tested model of green skills development in higher education (Wiek et al., 2011; Lozano et al., 2017). Second, it extends the predominantly Global North-focused literature by offering evidence from a Sub-Saharan African university context (Leal Filho et al., 2018). Third, it generates policy-relevant insights for aligning curriculum reform, campus practices, and institutional support systems with emerging sustainability and labour-market demands (OECD, 2022; UNESCO, 2017).

Conceptual Framework

This study is grounded in the growing body of literature that positions higher education institutions (HEIs) as key actors in advancing sustainable development through teaching, research, and institutional practice (Cortese, 2003; Lozano et al., 2017). Universities are increasingly expected not only to transmit disciplinary knowledge but also to develop green skills, understood as the knowledge, competencies, values, and behavioural capacities that enable individuals to contribute to environmentally sustainable outcomes in professional and societal contexts (OECD, 2022; UNESCO, 2017). From this perspective, the development of green skills is not solely an outcome of classroom instruction but a process shaped by the interaction of curriculum, institutional support, campus culture, and student learning experiences.

The conceptual framework of this study (Figure 1) integrates institutional, pedagogical, cognitive, and behavioural dimensions to explain how universities influence students' knowledge of environmental processes and their pro-environmental behavioural intentions and practices. Specifically, the framework links University Initiatives and Support for Green Skills Development (UISGSD), University Curriculum and Green Skills Integration (UCGSI), and University Environment and Culture (UEC) to Knowledge of Environmental Processes (KEP), which in turn relates to Behavioural Intentions and Practices (BIP). The model therefore adopts an institutional pathway perspective, in which student outcomes emerge through interconnected organisational and educational processes rather than through isolated instructional activities.

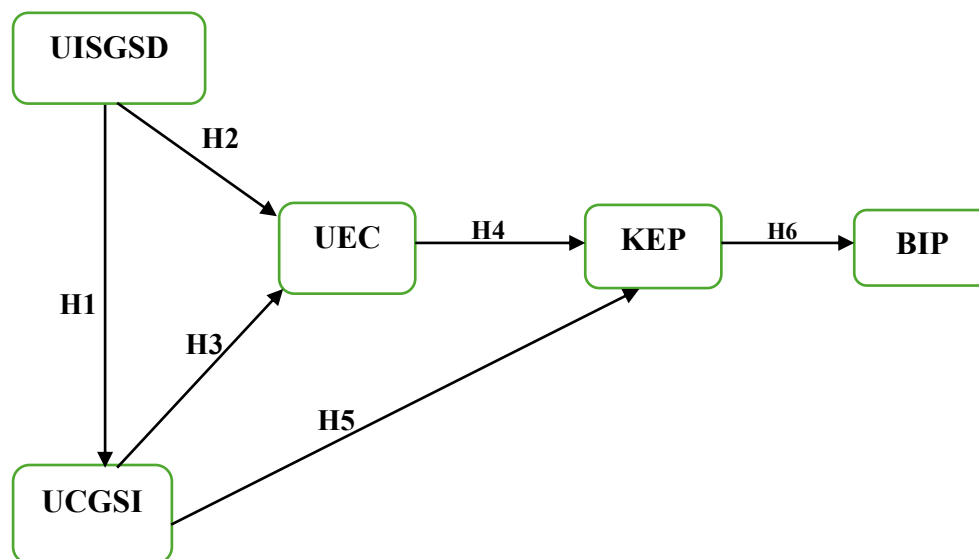


Fig. 1: Conceptual model

Theoretical Framework

The framework is informed by three complementary theoretical perspectives. Human Capital Theory views education as a process through which individuals acquire capabilities that enhance their effectiveness and productivity (Becker, 1993). In the context of sustainability education, this implies that green skills develop when universities provide learning

environments that support the acquisition and application of relevant knowledge and competencies. Institutional Theory further suggests that behaviour within organisations is shaped by structures, norms, and support systems that define what is valued and expected (Scott, 2014). From this perspective, institutional initiatives, curriculum design, and campus culture operate as organisational mechanisms that influence how sustainability-related learning occurs.

Insights from behavioural research, including the logic associated with the Theory of Planned Behavior (Ajzen, 1991), indicate that knowledge, social expectations, and enabling conditions may influence behavioural intentions. Rather than testing the full TPB model, the present study draws on this logic to examine how institutional and educational conditions contribute to the development of knowledge and behavioural orientation. This view is consistent with earlier work showing that sustainability-related competencies develop not only through individual learning but also through institutional arrangements that support the acquisition and application of human capital (Dankyi, 2020).

University Initiatives and Support for Green Skills Development (UISGSD)

University Initiatives and Support for Green Skills Development refer to the policies, strategies, resources, and programmes through which universities promote sustainability and green competencies. These initiatives may include sustainability governance structures, funding for green research and innovation, campus sustainability projects, partnerships with industry and communities, and institutional incentives that encourage environmentally responsible practices.

Existing literature consistently shows that institutional commitment is necessary for meaningful integration of sustainability in higher education (Cortese, 2003; Lozano et al., 2015). Without deliberate initiatives and sustained support, sustainability efforts often remain fragmented and peripheral. UISGSD is therefore expected to shape both curricular priorities and organisational culture.

Accordingly, Hypothesis 1 proposes that UISGSD is significantly related to University Curriculum and Green Skills Integration. Universities with strong sustainability policies are more likely to embed environmental and green skills content across disciplines and learning activities (Lozano et al., 2017; Wiek et al., 2011).

Hypothesis 2 proposes that UISGSD is significantly related to University Environment and Culture. Institutional initiatives signal normative expectations, influence leadership practices, and shape everyday campus experiences, thereby contributing to a culture in which sustainability becomes an accepted and reinforced value (Schein, 2017; Velazquez et al., 2006).

University Curriculum and Green Skills Integration (UCGSI)

University Curriculum and Green Skills Integration refers to the incorporation of sustainability concepts, environmental problem-solving, and green competencies into teaching, learning, and

assessment across academic programmes. This may include interdisciplinary coursework, experiential learning, sustainability case studies, and opportunities for applied learning related to real-world environmental challenges.

Curriculum integration is widely recognised as a central mechanism through which universities translate sustainability commitments into student learning outcomes (Sterling, 2010; Wiek et al., 2011). When sustainability is embedded across programmes rather than confined to isolated courses, students are more likely to develop transferable and applied green skills.

Hypothesis 3 therefore proposes that UCGSI is significantly related to University Environment and Culture. Curriculum practices can reinforce institutional norms by legitimising sustainability as a core academic value and encouraging pro-environmental attitudes among students and staff (Tilbury, 2011).

Hypothesis 5 proposes that UCGSI is significantly related to Knowledge of Environmental Processes. Previous studies indicate that curriculum-based sustainability education enhances students' understanding of ecological systems, environmental interdependencies, and human–environment relationships (Barth et al., 2007; UNESCO, 2017).

University Environment and Culture (UEC)

University Environment and Culture encompass the shared values, norms, social practices, and physical settings that characterise daily life within the university. This includes visible sustainability practices, leadership commitment, peer influence, institutional narratives, and the extent to which sustainable behaviour is encouraged or normalised.

From a socio-cultural learning perspective, learning occurs not only through formal instruction but also through participation in social contexts and exposure to institutional practices (Bandura, 1986; Schein, 2017). A sustainability-oriented campus environment therefore provides informal learning opportunities that complement curriculum-based instruction.

Hypothesis 4 proposes that University Environment and Culture is significantly related to Knowledge of Environmental Processes. Supportive institutional environments can strengthen students' environmental awareness and conceptual understanding through repeated exposure and engagement (Kollmuss & Agyeman, 2002; Leal Filho et al., 2018).

Knowledge of Environmental Processes (KEP)

Knowledge of Environmental Processes refers to students' cognitive understanding of ecological systems, environmental cause-and-effect relationships, resource flows, and sustainability challenges. Such knowledge is considered a foundational component of green skills because it supports higher-order competencies such as problem-solving, innovation, and responsible decision-making.

Environmental education research consistently identifies knowledge as an important, though not sufficient, condition for pro-environmental behaviour (Kollmuss & Agyeman, 2002). In the present framework, KEP represents a proximal learning outcome influenced by institutional initiatives, curriculum integration, and campus culture.

Behavioural Intentions and Practices (BIP)

Behavioural Intentions and Practices capture students' intentions to engage in environmentally responsible actions as well as their reported behaviours, including resource conservation, sustainable consumption, environmental advocacy, and the application of green skills in academic or professional contexts.

Drawing on behavioural research, intentions are often associated with actual behaviour when individuals possess relevant knowledge and perceive supportive conditions (Ajzen, 1991; Bamberg & Möser, 2007). Accordingly, Hypothesis 6 proposes that Knowledge of Environmental Processes is significantly related to Behavioural Intentions and Practices.

Summary of Hypothesis

H₁: University Initiatives and Support for Green Skills Development is significantly related to University Curriculum and Green Skills Integration.

H₂: University Initiatives and Support for Green Skills Development is significantly related to University Environment and Culture

H₃: University Curriculum and Green Skills Integration is significantly related to University Environment and Culture

H₄: University Environment and Culture is significantly related to Knowledge of Environmental Processes

H₅: University Curriculum and Green Skills Integration is significantly related to Knowledge of Environmental Processes

H₆: Knowledge of Environmental Processes and Behavioural Intentions and Practices are significantly related

Overall, the conceptual framework presents an institutional pathway model of green skills development in higher education, in which behavioural outcomes are associated with the interaction of institutional support, curriculum integration, campus culture, and cognitive learning. By empirically testing these relationships, the study contributes to the literature on sustainability education and provides evidence-based insights for universities seeking to align educational practice with sustainable development goals.

Empirical Review

Empirical research on sustainability education increasingly recognises that the development of green skills in higher education depends not only on curriculum content but also on the institutional context in which learning occurs. Studies across different higher education

systems show that universities that adopt comprehensive sustainability strategies tend to demonstrate stronger alignment between institutional initiatives, curriculum design, campus practices, and student learning outcomes. In such institutions, sustainability is not treated as an isolated subject but as a cross-cutting priority that influences teaching, research, and organisational practices (Cortese, 2003; Lozano et al., 2015; Leal Filho et al., 2018). Evidence suggests that where institutional leadership provides clear policy direction and allocates resources to sustainability programmes, academic units are more likely to integrate green skills into course content and learning activities (Chen, 2025; Tilbury, 2011). This relationship highlights the importance of institutional initiatives and support mechanisms as foundational drivers of sustainability integration within higher education.

Several studies further indicate that University Initiatives and Support for Green Skills Development are closely associated with curriculum reform. Universities that establish sustainability offices, develop environmental policies, or implement campus-wide green programmes often revise academic programmes to reflect these priorities. Akinsemolu and Onyeaka (2025) report that institutional support systems, including sustainability policies, research funding, and campus environmental projects, significantly enhance students' environmental knowledge and engagement by encouraging departments to incorporate sustainability topics into teaching and assessment. Similarly, research on Education for Sustainable Development shows that curriculum integration is more likely to occur when it is supported by institutional governance structures and strategic planning (Tilbury, 2011; UNESCO, 2017; Rieckmann, 2012). These findings suggest that institutional initiatives and curriculum integration operate as interrelated processes rather than independent activities.

Empirical evidence also supports the relationship between institutional initiatives and the broader university environment and culture. Universities that actively promote sustainability through policies, infrastructure, and student engagement programmes tend to develop campus environments in which environmentally responsible behaviour becomes socially expected. Abo-Khalil (2024) notes that initiatives such as campus decarbonisation projects, living laboratories, and community sustainability partnerships create practical settings where students can apply green skills, thereby reinforcing institutional norms that support environmental responsibility. When such initiatives are visible in everyday campus life, they influence students' perceptions of what behaviours are valued within the university. Research on organisational culture similarly shows that policies and leadership actions play a central role in shaping shared norms and practices (Schein, 2017). In the context of green skills development, this implies that institutional support contributes not only to curriculum change but also to the formation of a sustainability-oriented campus culture (Obiasor, Okafor, & Maduagwuna, 2025; Leal Filho et al., 2018).

The relationship between University Curriculum and Green Skills Integration and University Environment and Culture has also received empirical attention in the sustainability education literature. Education for Sustainable Development (ESD) research indicates that embedding sustainability across academic programmes influences students' attitudes and behaviours by legitimising environmental responsibility as a core academic value (UNESCO, 2024; Tilbury, 2011). When sustainability concepts are included in multiple courses and disciplines, students

encounter consistent messages that shape their understanding of environmental issues and their role in addressing them. Lad and Akerlof (2022) found that sustainability teaching is most effective when the institutional environment reflects the same principles that are promoted in the classroom. For example, when students learn about climate responsibility, circular economy principles, or ethical resource use, and simultaneously observe these practices in campus operations such as energy management, waste reduction, and procurement policies, the university environment reinforces curricular learning and contributes to the development of a sustainability-oriented culture. These findings suggest that curriculum integration and campus culture are mutually reinforcing, with each strengthening the impact of the other (Rieckmann, 2012; Wiek et al., 2011).

Empirical studies also indicate that curriculum integration plays an important role in shaping students' knowledge of environmental processes. Research on sustainability competencies shows that students who are exposed to interdisciplinary and problem-based sustainability courses demonstrate higher levels of environmental literacy and systems understanding (Barth et al., 2007; Wiek et al., 2011; Rieckmann, 2012). Curriculum designs that include experiential learning, case studies, and real-world environmental projects allow students to connect theoretical knowledge with practical applications, thereby improving their understanding of ecological relationships and sustainability challenges (Sterling, 2010; Lambrechts et al., 2013). However, some studies suggest that curriculum alone may not be sufficient to produce deep understanding unless it is supported by institutional practices and opportunities for engagement beyond the classroom (Leal Filho et al., 2018). This suggests that the effect of curriculum integration on environmental knowledge may depend on the broader institutional context in which learning occurs.

The influence of University Environment and Culture on Knowledge of Environmental Processes is also supported by empirical research. Learning theories emphasise that knowledge is shaped not only by formal instruction but also by social interaction and environmental exposure (Bandura, 1986). In university settings where sustainability is visible in daily practices, students are more likely to develop environmental awareness through observation, participation, and informal learning. Simiyu et al. (2022) found that social influence within the campus community significantly increases students' environmental knowledge, which in turn is associated with stronger pro-environmental orientation. Similarly, Lad and Akerlof (2022) argue that sustainability-oriented campus environments provide continuous cues that reinforce environmental learning, linking academic content to real-life experience. These findings support the view that campus culture can strengthen the development of environmental knowledge by providing repeated opportunities for engagement with sustainability practices (Leal Filho et al., 2018).

A substantial body of empirical research also examines the relationship between environmental knowledge and pro-environmental behaviour. Studies in environmental psychology suggest that knowledge is an important predictor of behavioural intention, although its influence is often moderated by social norms, perceived control, and institutional support (Kollmuss & Agyeman, 2002; Bamberg & Möser, 2007; Ajzen, 1991). In higher education contexts, students who demonstrate stronger understanding of environmental processes are more likely to express

intentions to engage in sustainable practices, particularly when they perceive that such behaviour is supported by their institutional environment (Steg & Vlek, 2009). These findings are consistent with sustainability competence research, which shows that behavioural outcomes are more likely when knowledge is reinforced through practical experience and supportive learning environments (Wiek et al., 2011; UNESCO, 2017).

More recent empirical work further suggests that institutional context plays a critical role in linking knowledge to behaviour. Universities that combine curriculum-based sustainability education with campus initiatives, student engagement programmes, and supportive organisational structures tend to report stronger behavioural outcomes among students. Studies of sustainability competencies indicate that behavioural change is more likely when students experience consistent messages across curriculum, campus practices, and institutional policies (Lozano et al., 2015; Leal Filho et al., 2018). This perspective aligns with research on human capital and organisational capability, which shows that the development of applied skills depends on institutional arrangements that enable learning, participation, and practice rather than on individual knowledge alone (Dankyi, 2020; Becker, 1993).

Despite the growing body of research on sustainability education, relatively few empirical studies have examined these relationships within a single integrated model that simultaneously considers institutional initiatives, curriculum integration, campus environment, environmental knowledge, and behavioural outcomes. Existing studies often focus on one dimension at a time, such as curriculum design or student attitudes, without analysing how institutional factors interact to shape learning processes. This limitation is particularly evident in Sub-Saharan Africa, where sustainability education is expanding but empirical, model-based evidence remains limited (Leal Filho et al., 2018; UNESCO, 2017). In the Ghanaian context, most studies on environmental education are descriptive, with little quantitative analysis of the institutional pathways through which green skills develop among university students.

The present study addresses this gap by empirically testing an institutional pathway model of green skills development in higher education. By examining the relationships among institutional initiatives, curriculum integration, campus environment and culture, environmental knowledge, and behavioural intentions and practices, the study provides a more comprehensive understanding of how universities contribute to the development of sustainability-related competencies, particularly within a Sub-Saharan African higher education context.

3. Methodology

3.1. Research Design

A quantitative, cross-sectional explanatory design was employed to test hypothesised structural relationships among institutional drivers and student green competencies. The approach supports estimation of direct, indirect (mediated), and moderating effects across latent constructs within a single integrated model.

3.2. Population, Sampling, and Participants

The target population comprised undergraduate students at a Ghanaian public university. Stratified random sampling ensured representation across STEM and non-STEM programmes. The final analytic sample was 353 students (age range 18–54 years; $M = 27$, $SD = 7.5$), 62.6% male and 37.4% female. Overall, 54.7% had taken at least one sustainability-related course and 29.5% reported participation in environmental or sustainability clubs.

3.3. Instrumentation

Data were collected using the Green Skills Competency Questionnaire (GSCQ), adapted from established education for sustainable development (ESD) measures to the Ghanaian context. The instrument comprised reflective indicators for five constructs: University Curriculum and Green Skills Integration (UCGSI), University Environment and Culture (UEC), University Initiatives and Support for Green Skills Development (UISGSD), Knowledge of Environmental Processes (KEP), and Behavioural Intentions and Practices (BIP). Responses were recorded on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Item refinement (removal of low-loading or duplicative indicators) preceded structural modeling.

3.4. Data Analysis

Analyses were conducted in SmartPLS 4.0 following contemporary recommendations for PLS-SEM (Hair et al., 2017, 2021, 2023). The two-stage evaluation comprised: (a) measurement model assessment; internal consistency (Cronbach's α , ρ_A , composite reliability), convergent validity ($AVE > .50$), and discriminant validity ($HTMT < .90$; Henseler et al., 2015), and (b) structural model assessment; multicollinearity ($VIF < 3.3$; Kock & Gaskins, 2014), path coefficients with significance via bootstrapping (5,000 resamples), and model fit indices including SRMR and NFI (Henseler et al., 2014; Jöreskog & Sörbom, 1981). Effect sizes (R^2 , f^2) and predictive relevance (Q^2) were also examined. Where theoretically warranted, moderation (interaction terms) and multi-group analysis (e.g., gender, programme field) were performed.

3.5. Ethical Considerations

Ethical approval was obtained from the host university's research ethics committee. Participation was voluntary and anonymous, and informed consent was obtained prior to data collection.

Results

Sociodemographic

The age of the study participants ranged from 18 to 54 years, with a mean age of 27 years (SD = 7.5). Table 1 presents the distribution of respondents according to sex, field of study, exposure to environmental or sustainability-related courses, and participation in sustainability-related activities.

Table 1: Characteristics of study participants

Item		Frequency	Percent
Sex	Male	221	62.6
	Female	132	37.4
Field of study	STEM	149	42.2
	Non-STEM	204	57.8
Taken course related to environmental sustainability	Yes	193	54.7
	No	160	45.3
Do you participate in environmental or sustainability club related activities	Yes	104	29.5
	No	249	70.5

It can be observed from Table 1 that the majority of respondents (62.6%) were male, while 37.4% were female. With regard to academic discipline, 42.2% of the students were enrolled in STEM programmes, whereas 57.8% were pursuing non-STEM programmes. In terms of exposure to sustainability education, 54.7% of the students reported that they had taken at least one course related to environmental sustainability, while 45.3% indicated that they had not taken any such course.

Participation in environmental or sustainability-related activities was relatively low, with only 29.5% of the respondents reporting involvement in environmental clubs or sustainability-related initiatives, compared to 70.5% who had not participated in such activities.

These characteristics indicate that although more than half of the students had some exposure to sustainability-related coursework, active engagement in sustainability-related activities remained limited among the respondents.

Results of the Model Evaluation

The proposed research model was estimated using SmartPLS 4.0 to examine the relationships among institutional factors, environmental knowledge, and behavioural intentions and practices. Consistent with recommended procedures for Partial Least Squares Structural Equation Modelling (PLS-SEM), the analysis was conducted in two stages. The first stage involved the evaluation of the measurement model to assess reliability, convergent validity, and discriminant validity of the constructs. The second stage focused on the evaluation of the structural model to test the hypothesised relationships among the latent variables.

The use of PLS-SEM was considered appropriate for this study because the objective was to examine predictive relationships among multiple latent constructs within a complex model, rather than to confirm a covariance-based theoretical structure. Following established guidelines for PLS-SEM, the assessment of the structural model included the examination of collinearity, path coefficients, coefficient of determination (R^2), effect significance through bootstrapping, and model fit indices.

Measurement Model

Measurement model analysis

The measurement model was evaluated to assess the reliability and validity of the constructs before examining the structural relationships. In line with recommended procedures for reflective measurement models in PLS-SEM, the assessment focused on indicator loadings, internal consistency reliability, convergent validity, and discriminant validity.

Reliability and Validity

Reliability and convergent validity were examined using outer loadings, Cronbach's alpha, composite reliability (ρ_A and ρ_C), and the average variance extracted (AVE). Following the estimation of the PLS algorithm, indicators with very low loadings were examined for potential removal in order to improve construct validity while maintaining conceptual consistency.

During this process, one indicator from the construct Knowledge of Environmental Processes (KEP) with a loading below the recommended threshold was removed. The removal of this item resulted in an improvement in the AVE value of the construct and enhanced the overall measurement quality. This decision was based not only on statistical criteria but also on consideration of content validity, ensuring that the retained indicators adequately represented the construct.

As presented in Table 2, the outer loadings ranged from 0.559 to 0.840, exceeding the minimum acceptable threshold of 0.50 for exploratory research. Cronbach's alpha values ranged from 0.859 to 0.945, while composite reliability (ρ_A) values ranged from 0.862 to 0.945, and composite reliability (ρ_C) ranged from 0.890 to 0.951. All values were above the recommended cut-off of 0.70, indicating satisfactory internal consistency reliability.

With respect to convergent validity, the AVE values ranged from 0.503 to 0.625 across all constructs, exceeding the minimum threshold of 0.50. These results confirm that the indicators adequately captured the variance of their respective latent constructs.

Table 2 presents the results of the reliability and convergent validity assessment.

Table 2: Reliability and Validity

Variables	Outer loading s	Cronbach's alpha	Composit e reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
BIP_	0.634	0.901	0.909	0.918	0.508
	0.765				
	0.573				
	0.559				
	0.705				
	0.716				
	0.725				
	0.745				
	0.796				
	0.782				
	0.790				
	0.790				
KEP_	0.715	0.859	0.862	0.890	0.503
	0.769				
	0.694				
	0.707				
	0.682				
	0.698				
	0.686				
	0.721				
UCGSI_	0.686	0.916	0.918	0.930	0.571
	0.772				
	0.763				
	0.726				
	0.669				
	0.787				
	0.736				
	0.817				
	0.798				
	0.789				
UEC_	0.718	0.945	0.945	0.951	0.565
	0.756				
	0.802				
	0.706				
	0.771				
	0.726				
	0.753				
	0.691				
	0.678				

	0.768				
	0.781				
	0.794				
	0.781				
	0.765				
	0.769				
UISGSD_	0.714	0.933	0.934	0.943	0.625
	0.785				
	0.755				
	0.799				
	0.813				
	0.809				
	0.798				
	0.840				
	0.797				
	0.787				

Key: University Initiatives and Support for Green Skills Development (UISGSD); University Curriculum and Green Skills Integration (UCGSI); University Environment and Culture (UEC); Knowledge of Environmental Processes (KEP); and Behavioural Intention and Practice (BIP).

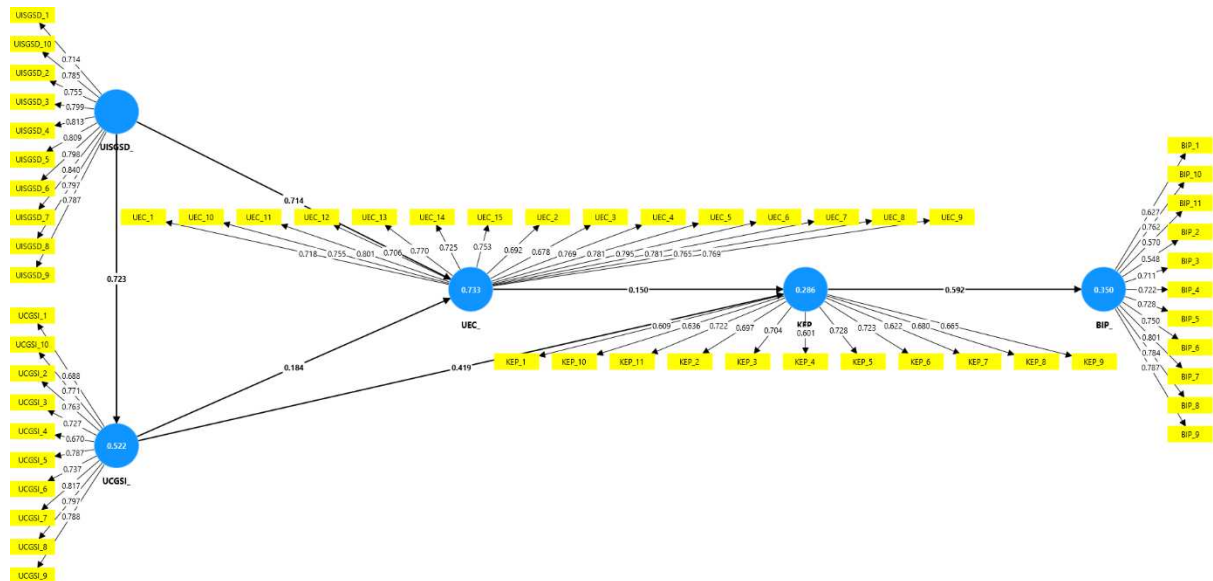


Fig 2: Exploratory PLS-SEM Image

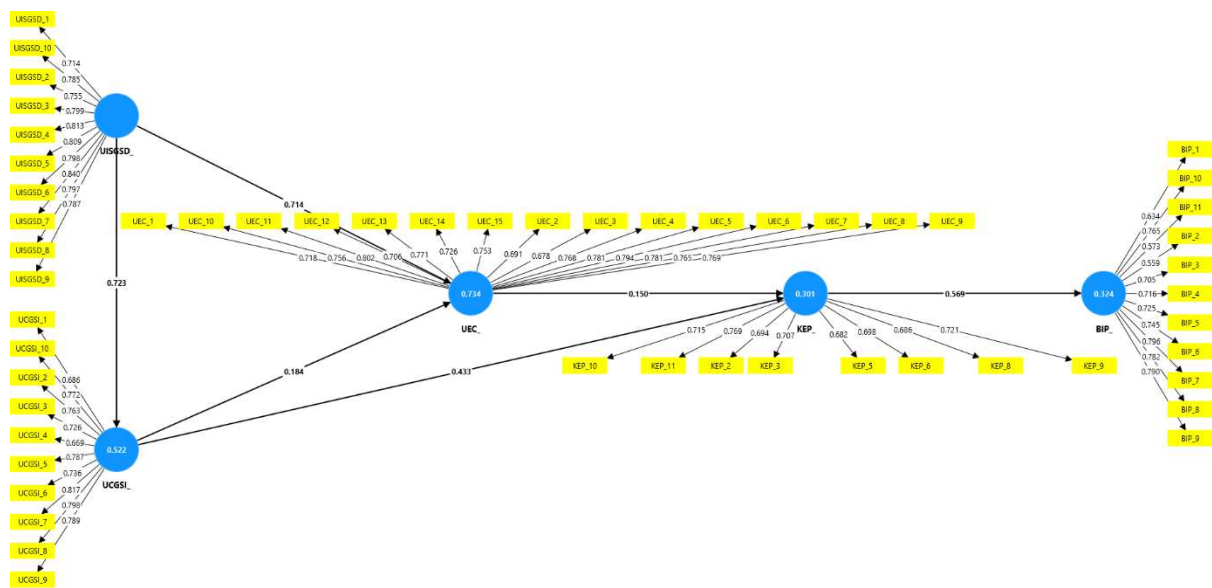


Fig 3: Structural model results of the PLS-SEM analysis

Figure 3 presents the final structural model estimated using PLS-SEM, showing the standardized path coefficients and the coefficient of determination (R^2) values for the endogenous constructs. The relationships illustrated in the figure correspond to the results reported in Table 5.

Multicollinearity

As recommended by Kock and Gaskins (2016), a multicollinearity assessment was conducted using the variance inflation factor (VIF) values. Table 2 shows that the VIF values ranged from 1.000 to 2.093. Based on the accepted threshold of VIF values below 3.3 (Kock & Gaskins, 2016), the results suggest that the estimated model was free from multicollinearity concerns.

Table 3: Variance Inflation Factor Values

Variables	BIP_	KEP_	UCGSI_	UEC_	UISGSD_
BIP					
KEP	1.000				
UCGSI_		1.961		2.093	
UEC_		1.961			
UISGSD_			1.000	2.093	

Key: University Initiatives and Support for Green Skills Development (UISGSD); University Curriculum and Green Skills Integration (UCGSI); University Environment and Culture (UEC); Knowledge of Environmental Processes (KEP); and Behavioural Intention and Practice (BIP).

Discriminant Validity

Heterotrait-Monotrait Ratio (HTMT)

Discriminant validity was assessed using the Heterotrait–Monotrait ratio (HTMT), which is considered a more reliable criterion for evaluating discriminant validity in PLS-SEM. According to recommended guidelines, HTMT values below 0.85 indicate strict discriminant validity, while values below 0.90 are considered acceptable in social science research.

The HTMT values for the constructs in this study ranged from 0.455 to 0.900, as presented in Table 4. Most of the values were below the more conservative threshold of 0.85, indicating satisfactory discriminant validity among the constructs. One HTMT value reached the upper acceptable limit (0.900) for the relationship between University Initiatives and Support for Green Skills Development (UISGSD) and University Environment and Culture (UEC). This result suggests a strong conceptual relationship between these constructs, which is theoretically plausible because institutional initiatives are expected to influence the broader campus environment and culture. However, since the value did not exceed the recommended maximum threshold, discriminant validity was considered acceptable.

Overall, the HTMT results confirm that the constructs measured in the study are empirically distinct while remaining conceptually related, supporting the adequacy of the measurement model for subsequent structural analysis.

Table 4 presents the HTMT results for the discriminant validity assessment.

Table 4: Results of the HTMT assessment for the discriminant validity

Variables	BIP_	KEP_	UCGSI_	UEC_	UISGSD_
BIP_					
KEP_	0.641				
UCGSI_	0.587	0.599			
UEC_	0.488	0.492	0.751		
UISGSD_	0.455	0.503	0.778	0.900	

Structural measurement

Assessment of Structural Model

After establishing the adequacy of the measurement model, the structural model was evaluated to examine the hypothesised relationships among the constructs. The assessment of the structural model followed recommended PLS-SEM procedures, including the examination of collinearity, path coefficients, statistical significance, and the explanatory power of the model. To test the proposed hypotheses, a bootstrapping procedure with 5,000 resamples was performed. Bootstrapping is a non-parametric resampling technique that allows the estimation of standard errors, t-statistics, and confidence intervals without assuming normality of the data. This approach is considered appropriate for PLS-SEM, particularly when the model involves multiple latent constructs and complex relationships.

The significance of the structural paths was evaluated using the standardized path coefficients (β), t-statistics, p-values, and confidence intervals. A relationship was considered statistically significant when the p-value was less than 0.05 and the confidence interval did not include zero.

The results of the path analysis are presented in Table 5.

Path Analysis and Hypotheses Testing

To evaluate the proposed hypotheses, the structural model was analysed using the bootstrapping procedure with 5,000 resamples. The standardized path coefficients, t-statistics, p-values, and confidence intervals were examined to determine the strength and significance of the relationships among the constructs. The results of the hypothesis testing are presented in Table 5.

The results indicated that University Initiatives and Support for Green Skills Development (UISGSD) had a strong and statistically significant positive relationship with University Curriculum and Green Skills Integration (UCGSI) ($\beta = 0.723$, $t = 24.228$, $p < 0.001$). This finding suggests that when universities provide institutional support, policies, and resources for sustainability, curriculum integration of green skills is more likely to occur.

Similarly, UISGSD showed a significant positive relationship with University Environment and Culture (UEC) ($\beta = 0.714$, $t = 15.413$, $p < 0.001$), indicating that institutional initiatives are closely associated with the development of a sustainability-oriented campus environment and culture.

The results also revealed a significant relationship between University Curriculum and Green Skills Integration and University Environment and Culture ($\beta = 0.184$, $t = 3.511$, $p < 0.001$). This suggests that the integration of sustainability-related content within academic programmes contributes to shaping the broader institutional environment and culture.

With regard to knowledge outcomes, University Environment and Culture had a significant positive relationship with Knowledge of Environmental Processes (KEP) ($\beta = 0.150$, $t = 2.366$, $p = 0.018$). This result indicates that exposure to a sustainability-oriented campus environment is associated with higher levels of environmental knowledge among students.

In addition, University Curriculum and Green Skills Integration showed a strong and statistically significant relationship with Knowledge of Environmental Processes ($\beta = 0.433$, $t = 7.021$, $p < 0.001$), demonstrating that the inclusion of sustainability concepts within the curriculum plays an important role in improving students' understanding of environmental issues.

Finally, Knowledge of Environmental Processes was found to have a strong positive relationship with Behavioural Intentions and Practices (BIP) ($\beta = 0.569$, $t = 10.523$, $p < 0.001$). This finding indicates that students with higher levels of environmental knowledge are more likely to report pro-environmental intentions and practices.

Overall, the results support all the hypothesised relationships in the proposed model, suggesting that institutional initiatives, curriculum integration, and campus environment operate together as interconnected pathways through which environmental knowledge and behavioural outcomes develop among university students.

Table 5: Path significance test

Relationships	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values	2.5%	97.5%
UISGSD-> UCGSI	0.723	0.725	0.030	24.228	0.000	0.661	0.780
UISGSD-> UEC	0.714	0.715	0.046	15.413	0.000	0.623	0.805
UCGSI -> UEC	0.184	0.183	0.052	3.511	0.000	0.079	0.284
UEC->KEP	0.150	0.151	0.063	2.366	0.018	0.026	0.274
UCGSI-> KEP	0.433	0.436	0.062	7.021	0.000	0.318	0.556
KEP-> BIP	0.569	0.576	0.054	10.523	0.000	0.461	0.673

Key: University Initiatives and Support for Green Skills Development (UISGSD); University Curriculum and Green Skills Integration (UCGSI); University Environment and Culture

(UEC); Knowledge of Environmental Processes (KEP); and Behavioural Intention and Practice (BIP).

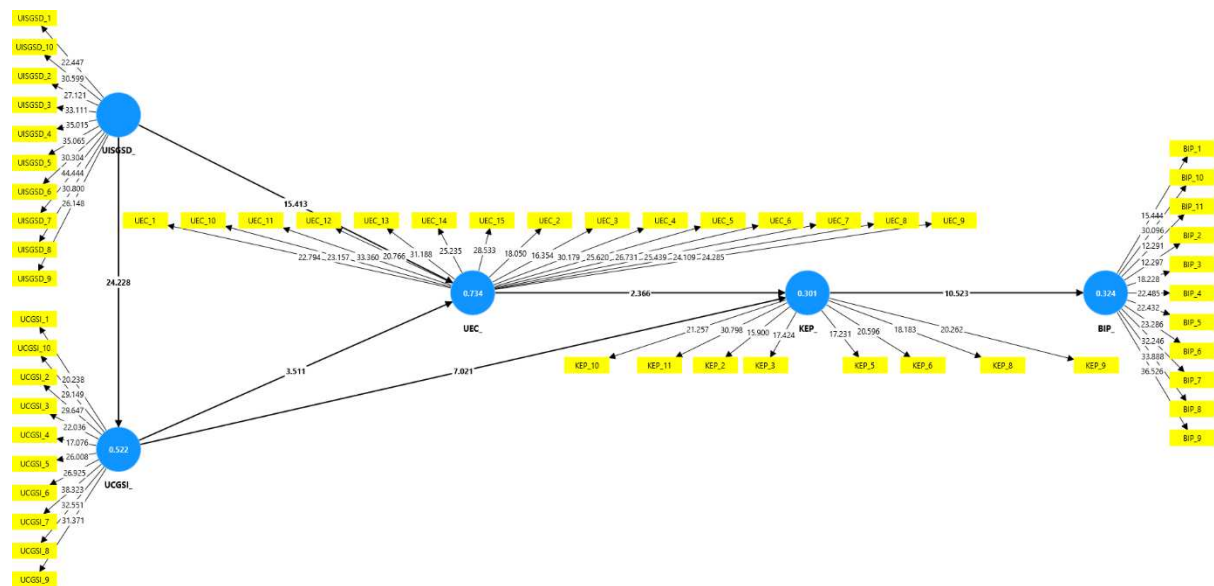


Fig. 3: PLS-SEM Bootstrap Image

Model Fit Assessment

To evaluate the adequacy of the structural model, model fit indices recommended for PLS-SEM were examined. These included the Standardized Root Mean Square Residual (SRMR), the squared Euclidean distance (d_ULS), the geodesic discrepancy (d_G), the chi-square statistic, and the Normed Fit Index (NFI). These indices provide an indication of how well the estimated model reproduces the observed data.

As shown in Table 6, the SRMR value for the saturated model was 0.062, while the SRMR for the estimated model was 0.081. Values of SRMR below 0.08 are generally considered to indicate a good fit, while values slightly above this threshold may still be regarded as acceptable in complex models estimated using PLS-SEM. The SRMR values obtained in this study therefore suggest an acceptable level of model fit.

The values of d_ULS and d_G for the estimated model were higher than those of the saturated model, which is expected, since the saturated model represents the best possible fit to the data. The chi-square values for both the saturated and estimated models also showed only small differences, indicating that the proposed structural model does not substantially deviate from the observed data.

The Normed Fit Index (NFI) values for the saturated model (0.759) and the estimated model (0.757) were below the conventional threshold of 0.90; however, NFI values in PLS-SEM are typically interpreted with caution and are not considered the primary criterion for model evaluation. Given the exploratory and predictive nature of the present model, the overall pattern of fit indices suggests that the model demonstrates an acceptable level of fit and is suitable for interpretation of the structural relationships.

Table 6 presents the model fit statistics.

Table 6: Goodness of fit

Variables	Saturated model	Estimated model
SRMR	0.062	0.081
d_ ULS	5.683	9.740
d_ G	1.767	1.797
Chi-square	3311.850	3341.620
NFI	0.759	0.757

Coefficient of Determination (R^2)

The explanatory power of the structural model was assessed using the coefficient of determination (R^2), which represents the proportion of variance in each endogenous construct explained by its predictor variables. In PLS-SEM, R^2 values of 0.25, 0.50, and 0.75 are commonly interpreted as weak, moderate, and substantial levels of explanatory power, respectively.

As shown in Table 7, the model explained a substantial proportion of the variance in University Curriculum and Green Skills Integration (UCGSI), with an R^2 value of 0.523, indicating that institutional initiatives and support accounted for 52.3% of the variance in curriculum integration.

For University Environment and Culture (UEC), the R^2 value was 0.734, suggesting that University Initiatives and Support for Green Skills Development together with Curriculum Integration explained 73.4% of the variance in the institutional environment and culture related to sustainability. This indicates a strong level of explanatory power for this construct.

The R^2 value for Knowledge of Environmental Processes (KEP) was 0.538, meaning that Curriculum Integration and University Environment and Culture jointly explained 53.8% of the variance in students' environmental knowledge. This reflects a moderate to substantial level of explanatory power.

Finally, the R^2 value for Behavioural Intentions and Practices (BIP) was 0.323, indicating that Knowledge of Environmental Processes explained 32.3% of the variance in behavioural intentions and practices. This level of variance explained can be considered moderate in behavioural and social science research, where behaviour is influenced by multiple factors.

Overall, these results suggest that the proposed model demonstrates satisfactory explanatory power, particularly for curriculum integration, institutional environment, and environmental knowledge, while behavioural outcomes show a moderate level of variance explained.

Table 7 presents the R^2 values for the endogenous constructs.

Table 7: Coefficient of Determination (R^2)

Variables	R-square	R-square adjusted
KEP	0.301	0.297
UCGSI	0.522	0.521
UEC	0.734	0.732

DISCUSSION

This study examined the institutional pathways through which green skills develop among university students by analysing the relationships between institutional initiatives and support, curriculum integration, campus environment and culture, environmental knowledge, and behavioural intentions and practices. The results indicate that green skills development in higher education is not driven by a single factor but emerges from an interconnected institutional system in which governance structures, curriculum design, and campus culture jointly shape students' knowledge and behavioural orientation. Rather than operating as independent influences, these factors function as interrelated pathways through which sustainability competencies are developed. This finding supports the growing view that sustainability education requires a whole-institution approach rather than isolated curricular interventions (Lozano et al., 2015; UNESCO, 2020).

The strong relationship between university initiatives and curriculum integration suggests that formal institutional commitment plays a foundational role in embedding sustainability within academic programmes. When universities adopt explicit sustainability policies, allocate resources, and promote staff development, they create conditions that enable green competencies to be systematically incorporated into teaching and learning. Similar findings have been reported in studies showing that institutional leadership and policy frameworks are critical drivers of sustainability integration in higher education (Chen et al., 2025; Lozano et al., 2015). From an institutional theory perspective, such initiatives provide legitimacy and direction, signalling that sustainability is not an optional activity but an organisational priority (Scott, 2014).

Institutional initiatives were also strongly associated with the university environment and culture, indicating that sustainability practices become embedded in everyday campus life when supported by governance, policies, and programmes. This result reinforces the argument that campus culture is not merely a reflection of individual attitudes but an outcome of organisational structures and practices. Previous studies have shown that universities that integrate sustainability into operations, student activities, and communication create social norms that encourage pro-environmental behaviour (Abo-Khalil, 2024; Obiasor et al., 2025). In this sense, the campus environment functions as a living context in which students observe, experience, and internalise sustainability values.

The significant relationship between curriculum integration and campus environment further highlights the importance of alignment between teaching and institutional practice. When sustainability concepts are incorporated into courses while also being reflected in campus operations, students encounter consistent messages across formal and informal learning settings. This supports earlier work suggesting that sustainability education is most effective when academic content is reinforced by experiential and institutional learning environments (Lad & Akerlof, 2022; Sterling, 2010). Such alignment helps move sustainability from theoretical knowledge to lived experience, strengthening both understanding and commitment.

The findings also show that both curriculum integration and campus culture are positively associated with students' knowledge of environmental processes. This suggests that environmental knowledge develops through multiple channels, including formal instruction, peer interaction, and exposure to sustainability practices within the university. Social learning theory provides a useful explanation for this pattern, as knowledge is shaped not only through direct teaching but also through observation and participation in social contexts (Bandura, 1986). Studies of sustainability literacy similarly indicate that students' understanding of environmental systems improves when learning is supported by institutional practices, campaigns, and co-curricular activities (Simiyu et al., 2022).

An important result of the study is the significant positive relationship between environmental knowledge and behavioural intentions and practices. Students who demonstrated a higher level of understanding of environmental processes were more likely to report stronger pro-environmental intentions and behaviours. Although previous research often reports a knowledge-behaviour gap in sustainability studies (Kollmuss & Agyeman, 2002), the present findings indicate that this gap may be reduced when learning occurs within a supportive institutional context. When curriculum, campus culture, and institutional initiatives operate together, knowledge becomes more actionable because students are provided with opportunities, resources, and social reinforcement for sustainable behaviour.

The results further demonstrate that institutional initiatives influence behavioural outcomes indirectly through curriculum integration, campus culture, and knowledge development. This pattern suggests that green skills are not produced solely through classroom instruction but through an institutional process in which governance, learning, and environment operate together. Similar conclusions have been drawn in studies of sustainability competencies, which emphasise that skills such as systems thinking, responsibility, and action competence develop through integrated learning environments rather than through isolated courses (Wiek et al., 2011). In this sense, green skills should be understood not only as individual attributes but also as capabilities enabled by organisational structures and learning contexts. Previous research has similarly shown that the development of human capital for sustainability depends on institutional arrangements that support learning, collaboration, and practical engagement (Dankyi, 2020).

From a theoretical standpoint, the findings extend human capital and behavioural perspectives by demonstrating the importance of organisational context in shaping learning outcomes. While human capital theory assumes that education enhances skills that lead to improved performance, the present results suggest that institutional conditions determine whether such skills become actionable. Likewise, behavioural theories emphasise the role of cognition in guiding action, but the current model indicates that institutional support and campus culture can strengthen the link between knowledge and behaviour by reducing practical and social barriers to engagement. In this respect, institutional initiatives function as enabling mechanisms that make sustainability practices more feasible and socially supported within the university environment.

These findings have particular relevance for higher education systems in developing contexts, where universities are increasingly expected to contribute to environmental sustainability and green transitions despite limited resources. The results suggest that curriculum reform alone may not be sufficient to produce meaningful behavioural outcomes unless it is accompanied by sustained institutional commitment and supportive campus environments. International policy reports emphasise that the development of green skills requires coordinated action across education systems, organisational structures, and labour-market demands (OECD, 2012; ILO, 2019). Evidence from developing economies also indicates that sustainability-related competencies are more likely to emerge when educational systems are supported by institutional and economic structures that promote innovation and capability development (Dankyi & Abban, 2022).

Overall, the study provides empirical support for an institutional pathway model of green skills development, in which initiatives, curriculum, and campus culture operate together to influence knowledge and behavioural intentions. This integrated perspective reinforces the importance of whole-institution approaches to sustainability in higher education and highlights the need to view green skills not only as individual competencies but also as outcomes shaped by organisational systems, learning environments, and institutional commitment.

Theoretical Contributions

The findings of this study contribute to the theoretical understanding of pro-environmental behaviour in higher education by extending the application of the Theory of Planned Behaviour (TPB) to an institutional context. Traditional TPB formulations conceptualise behavioural intention as a function of individual-level determinants such as attitudes, subjective norms, and perceived behavioural control (Ajzen, 1991). However, the present findings suggest that these individual-level determinants may themselves be shaped by broader institutional conditions within the university environment. In particular, University Initiatives and Support for Green Skills Development (UISGSD), University Curriculum and Green Skills Integration (UCGSI), and University Environment and Culture (UEC) were found to operate as system-level factors that indirectly influence Behavioural Intention and Practice (BIP) through their effects on learning experiences and knowledge development.

Rather than contradicting TPB, these results provide a contextual extension by demonstrating how higher-education institutions can influence the antecedent conditions that TPB assumes at the individual level. Institutional initiatives, curriculum structures, and campus culture may contribute to the formation of norms, beliefs, and perceived opportunities for action, thereby shaping behavioural orientation in ways that are not fully captured when TPB is applied only at the individual level. This interpretation is consistent with research suggesting that pro-environmental behaviour is influenced not only by personal attitudes but also by organisational and social contexts that enable or constrain action (Kollmuss & Agyeman, 2002; Lozano et al., 2015).

A further contribution of the study lies in the significant relationship observed between Knowledge of Environmental Processes (KEP) and Behavioural Intention and Practice (BIP). Within TPB, knowledge is not explicitly modelled as a core construct, yet it may play an important role in shaping attitudes and perceived behavioural control, particularly in domains that require technical or systems understanding. The present findings suggest that domain-specific environmental knowledge functions as a cognitive resource that supports pro-environmental intentions, especially when reinforced by supportive institutional conditions. This aligns with previous studies indicating that environmental literacy can strengthen behavioural commitment when individuals perceive that they have the understanding and capacity to act (Kollmuss & Agyeman, 2002; Wiek et al., 2011).

Importantly, the results indicate that knowledge does not develop in isolation but is significantly influenced by curriculum integration and campus environment, both of which are shaped by institutional initiatives. This pattern highlights the role of higher-education institutions as active agents in the development of sustainability competencies, rather than neutral settings in which individual attitudes are formed independently. Such a perspective is consistent with institutional and human-capital approaches, which emphasise that the acquisition of skills depends on organisational structures that support learning, participation, and practice (Scott, 2014; Dankyi, 2020).

By demonstrating that behavioural intentions are linked to knowledge, and that knowledge is influenced by curriculum and institutional context, the study proposes an institutional pathway model of green skills development. This model complements TPB by situating individual behavioural processes within a structured educational environment, thereby providing a more comprehensive explanation of how sustainability-related competencies emerge in higher education. The findings therefore contribute to the growing literature that calls for integrating behavioural theory with whole-institution approaches to sustainability education (UNESCO, 2020; Lozano et al., 2015).

Policy Implications and Recommendations

The findings of this study carry important implications for higher education policy, particularly in contexts such as Ghana where universities are increasingly expected to contribute to sustainable development and the transition toward green economies. Rather than treating green skills development as a purely curricular matter, the results indicate that effective policy interventions must address the broader institutional conditions that allow sustainability learning to translate into meaningful knowledge and behavioural outcomes. This supports the growing argument that sustainability education requires whole-institution approaches that integrate governance, curriculum, and campus practices (UNESCO, 2020; Lozano et al., 2015).

First, the strong and consistent influence of university initiatives and support mechanisms suggests that green skills development should be institutionalised within national higher education policy frameworks rather than confined to individual courses or departments. Institutional initiatives were found to shape curriculum integration and campus culture, which in turn influence students' knowledge and behavioural intentions. From a policy perspective,

this implies that sustainability-related competencies should be embedded within quality assurance, accreditation, and institutional performance assessment systems. In the Ghanaian context, such an approach aligns with the objectives of the Education Strategic Plan and the mandate of the Ghana Tertiary Education Commission (GTEC) to promote relevance, quality, and responsiveness in higher education. It also reflects the principles of SDG 4.7, which emphasises education for sustainable development as a system-wide responsibility rather than a subject-specific requirement.

Second, the significant relationship between curriculum integration and environmental knowledge highlights the importance of meaningful and well-structured incorporation of sustainability within academic programmes. The results indicate that curriculum reform can enhance students' understanding of environmental processes, but its effectiveness depends on the extent to which integration is supported by institutional resources, staff capacity, and appropriate pedagogical approaches. Policy frameworks that focus only on adding sustainability-related courses may therefore produce limited impact unless accompanied by investments in lecturer training, experiential learning opportunities, and institutional coordination. In the context of Ghana's climate commitments, including the National Climate Change Policy and the country's Nationally Determined Contributions, higher education reforms should prioritise institutional capacity-building alongside curriculum development.

Third, the significant role of university environment and culture in shaping students' knowledge underscores the importance of campus operations as a policy-relevant learning space. When sustainability is reflected in energy use, waste management, procurement practices, and student engagement activities, the campus becomes a practical environment in which students can observe and experience sustainability principles. Such findings support the idea that universities can function as "living laboratories" for sustainable development, where learning extends beyond the classroom into everyday institutional practice. From a policy standpoint, this suggests that higher education policy should encourage stronger links between academic programmes, campus management, and national environmental standards. In the Ghanaian context, this approach would support progress toward SDG 11 (sustainable communities) and SDG 13 (climate action), while strengthening the role of universities in national sustainability efforts.

Fourth, the positive relationship between environmental knowledge and behavioural intentions indicates that knowledge plays an important role in shaping students' orientation toward sustainable practices, particularly when supported by enabling institutional conditions. Although knowledge alone may not guarantee behaviour change, the results suggest that students are more likely to express pro-environmental intentions when their understanding of environmental processes is reinforced by curriculum integration, supportive campus environments, and institutional initiatives. This finding has implications for policy design, as it highlights the need to combine education with opportunities for practical engagement, student participation, and institutional support for sustainability activities. Such an approach is consistent with Ghana's broader youth employment and green economy objectives under SDG 8, which emphasise the development of skills that are both knowledge-based and applicable in real-world contexts.

Finally, the substantial explanatory power of the institutional variables in the model highlights the importance of evidence-based policy monitoring in higher education systems. The results suggest that institutional conditions can account for a significant proportion of variation in curriculum integration, campus culture, and environmental knowledge, indicating that these factors are measurable and policy-relevant. National higher education systems would therefore benefit from incorporating green skills indicators into routine data collection, quality assurance, and institutional reporting frameworks. In Ghana, this aligns with the monitoring functions of the National Development Planning Commission and ongoing efforts to strengthen data-driven decision-making across the public sector. From a research perspective, improved data systems would also support comparative studies of sustainability education across institutions and regions.

Taken together, these policy implications suggest that aligning higher education with national and global sustainability goals requires a shift from programme-level interventions toward institution-level policy design. By strengthening governance structures, supporting campus-based sustainability practices, and embedding green skills within national quality assurance systems, higher education policy can more effectively contribute to sustainable development pathways in Ghana and comparable Sub-Saharan African contexts.

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Clinical trial number: not applicable

Ethical Approval and Accordance

The study received ethical approval from the Institutional Review Board of the University of Cape Coast, Ghana Approval Number: UCCIRB/EXT/2024/0057. All research procedures were reviewed and approved by the Board and were conducted in accordance with the ethical guidelines and regulations of the University of Cape Coast. The study was further carried out in accordance with the principles of the Declaration of Helsinki and other applicable ethical standards governing research involving human participants. Participation in the study was voluntary, and informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality and anonymity, and no personally identifiable information was disclosed in the reporting of the findings.

In addition, all co-authors reviewed and consented to the final manuscript before submission for publication. This ensured that the manuscript reflected the collective agreement of the authors and complied with ethical publication standards.

Consent to Participate

Informed consent was obtained from all participants prior to their participation in the study. Participants were provided with information regarding the purpose of the research, the

voluntary nature of participation, their right to withdraw at any stage without penalty, and the measures taken to ensure confidentiality and anonymity. Only individuals who freely agreed to participate and provided informed consent were included in the study.

Data Availability Statement

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

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