

Environmental culture and recycling in higher education: an integrative review for the University of Guayaquil

Villa-Manosalvas Gonzalo Iván^{1*}, Villa-Cox Viviana Teresa¹, Pérez-Benítez Hugo Alfredo¹, Haro-Guanga Sócrates Emilio¹

¹Universidad de Guayaquil, Guayaquil, Ecuador

¹ORCID: <https://orcid.org/0000-0002-9321-9436> | Email: gonzalo.villam@ug.edu.ec

¹ORCID: <https://orcid.org/0009-0006-0743-2350> | Email: viviana.villac@ug.edu.ec

¹ORCID: <https://orcid.org/0000-0001-7460-4032> | Email: hugo.pereza@ug.edu.ec

¹ORCID: <https://orcid.org/0000-0002-8957-6350> | Email: socrates.haro@ug.edu.ec

***Corresponding Author:** Villa-Manosalvas Gonzalo Iván, Universidad de Guayaquil, Guayaquil, Ecuador | ORCID: <https://orcid.org/0000-0002-9321-9436> | Email: gonzalo.villam@ug.edu.ec

Abstract

Introduction: universities fulfill two roles, firstly, being an urban microcosm, they generate a large amount of solid waste, but they are also training institutions that educate those who will have the responsibility of leading the transition to circular economy, in these conditions campuses are fertile ground to cultivate environmental culture. Objective: To synthesize and present recent evidence on environmental education and culture strategies aimed at recycling in HEIs, which allow deriving guidelines applicable to the UG.

Methodology: The integrative review method of Whitemore and Knafl was employed; multidisciplinary databases were searched; for screening, an adaptation of PRISMA 2020 was used; and study quality was assessed using the MMAT tool for mixed-methods studies. The final corpus comprised empirical studies published between 2020 and 2026, which were grouped into five categories: knowledge; attitudes and values; practices; pedagogical-institutional strategies; and barriers and facilitators.

Results: Environmental knowledge proved to be necessary but not sufficient. Pro-environmental attitudes bridge the gap between knowledge and action. Experiential and curriculum-based interventions produce measurable improvements in solid waste management; however, these gains diminish in the absence of adequate infrastructure and sociocultural support.

Conclusions: A university recycling culture does not stem from any single factor; it depends on the alignment of environmental education, institutional governance, and infrastructure. This relationship provides the basis for the strategic guidelines proposed for the University of Guayaquil.

Keywords: Environmental culture, circular economy, environmental education, higher education institutions, recycling, solid waste.

Highlights

- Environmental knowledge is a necessary but insufficient condition for recycling.
- Pro-environmental attitudes mediate between knowledge and recycling behavior.
- Experiential interventions go beyond merely informative teaching.
- Infrastructure and governance decide the move from intention to action.
- Five recycling culture guidelines are proposed for the University of Guayaquil.

Introduction

General Context

Solid waste management is an issue that socio-environmental policies cannot ignore, as it intertwines political, socioeconomic, institutional, and environmental dimensions (Debrah et al., 2021). The accelerated urban development of recent decades has caused its waste to grow to the same extent. The result is a structural challenge for developing economies, where the scarcity of infrastructure and technical resources coexists with increasing regulatory pressure to move towards circular models (Debrah et al., 2021; Ferronato et al., 2020).

The transition from the linear economic model (extract, produce, discard) to a circular economy, which incorporates waste and converts it into resources, has been consolidated as a public policy horizon. Transition has been affirmed as a consolidated object of interdisciplinary research (Nagatomo, 2024; Stephan et al., 2020; Vergani, 2024).

Within this transition, higher education institutions (HEIs) occupy a unique position, because their campuses function as urban microcosms. They have very high concentrations of population that generate waste of a very different nature, such as paper, cardboard, plastics, food waste, electronic waste and laboratory waste. Its management reproduces the complex municipal situation on a scale (Owojori et al., 2020; Rodríguez-Guerreiro et al., 2024; Stephan et al., 2020; Vergani, 2024).

Rodríguez-Guerreiro et al. (2024) measured the waste generated on average by a person in universities around the world and reported 0.19 ± 0.21 kg per person per day, with a predominance of organics ($30 \pm 19\%$), followed by paper and cardboard. These data reveal that the problem is real in material terms and highly variable depending on the context.

In this reality, however, universities are continuously training the new generations who are going to lead the ecological transition in values, knowledge, and practices (Manfredi et al., 2021; Owojori et al., 2022; Vergani, 2024). This double condition, i.e. being both a source of waste and an agent of cultural transformation, places HEIs at the centre of any serious sustainability strategy.

By fulfilling this role, universities connect with the 2030 Agenda, through two Sustainable Development Goals, SDG 11 which deals with sustainable cities and communities and SDG 12 on responsible production and consumption (Abdulghaffar & Williams, 2021; Sen et al., 2021). Authors such as Alazaiza et al. (2024) and Owojori et al. (2022) attribute specific social responsibilities to HEIs such as raising awareness of both the university community and its political-social environment on the importance of waste management.

The sustainability strategies of Australian universities were studied by Sen et al. (2021), who reported that achieving carbon neutrality and meeting waste diversion goals depends much more on HEIs themselves incorporating sustainability into their teaching, research, and campus operations, than on purely technical conditions.

This global panorama is reflected in Ecuadorian regulations, since the Organic Environmental Code (National Assembly of Ecuador, 2017) declared integrated waste management a national priority. Ministerial Agreement 061 (Ministry of the Environment of Ecuador, 2015) established the technical regime for non-hazardous and special waste. More recently, the National Strategy for the Inclusive Circular Economy (Ecuador, 2021) has articulated public policy axes, such as innovation and sustainable consumption.

This regulatory support offers the University of Guayaquil, one of the largest institutions of higher education in the country, an explicit legal basis to design and implement a solid waste management system based on recycling and the formation of an environmental culture, also articulated with regional experiences that have already tested circular economy models in Ecuador (Garabiza et al., 2021).

State of the art

Recent literature has addressed university recycling from multiple disciplinary angles, which in the case of this review is organized into five analytical axes: environmental knowledge, attitudes and values, practices and behaviors, pedagogical-institutional strategies, and sociocultural barriers and facilitators. Each axis is based on a consolidated theoretical construct, on whose development depends how the findings are interpreted and how this synthesis was operationalized.

The first axis places environmental knowledge as the cognitive basis of recycling behavior. Frick et al. (2004) distinguished three types of knowledge: systems, action, and effectiveness. The contribution of this typology changed the approach: it is no longer only factual information that matters, but the knowledge that really drives

action. This line of research is still in force in universities, where it is argued that the lack of knowledge aggravates the problems arising from waste management, especially in developing countries, and from this arise numerous diagnoses and training proposals (Debrah et al., 2021). This is a half-correct posture, because more is needed.

Attitudes and values shape the second axis, which is affirmed on the scale of the New Ecological Paradigm of Dunlap et al. (2000), consolidated as the way to measure the pro-environmental approach at a general level, which allowed, over two decades, to document the diffusion of an ecological awareness that, even so, rarely translates linearly into behavior.

This relationship was addressed by subsequent research, which showed that the affective component acts as a bridge between knowledge and action, although it is conditioned by contextual and cultural factors, which by their nature are difficult to fully quantify. That is why attitude can be measured, but, even so, it is not enough.

Within the third axis, observable practices and behaviors are addressed, theoretically dominated by Ajzen's (1991) Theory of Planned Behavior, its triad of attitude, subjective norm and perceived behavioral control, has become the most widely used predictive framework to explain separation and recycling behavior, and has demonstrated a remarkable ability to adapt to contexts as diverse as the recycling of electronic waste. municipal separation or waste management by academic staff, then the incorporation of perceived behavioral control was especially fruitful, since it explicitly introduced the role of material conditions, the available infrastructure, in the very possibility of acting. Intent alone does not guarantee action.

We propose the fourth axis, central to this review, where pedagogical and institutional strategies are brought together, and we find that the model of behavioral change in environmental education of Hungerford and Volk (1990) anticipated that the formation of responsible environmental behaviors depends on input, ownership and empowerment variables, a scheme that contemporary interventions have operationalized in modalities ranging from curricular integration to playful pedagogy and service-learning.

The analysis of the studies reviewed raises a warning: education understood as the simple delivery of information raises awareness, but does not ensure behavior change (Manfredi et al., 2021). To analyze how barriers and sociocultural facilitators that mediate between action and intention affect it, a fifth axis is proposed. Kollmuss and Agyeman's (2002) formulation of the gap between value and action helps to interpret why favorable attitudes do not become behavior. In addition, there is evidence that presents higher education, in itself, as a structural facilitator of pro-environmental behavior (Kountouris & Remoundou, 2023).

The reviews that map management practices and the institutionalization of university recycling converge in pointing out that there are still infrastructure and governance gaps (Rodríguez-Guerreiro et al., 2024; Vergani, 2024). The evidence that brings these five axes together in universities is abundant, but it comes mostly from Europe, Asia and North America, while Ibero-American production remains small and dispersed. This review sorts that evidence and condenses it, study by study, in Table 1.

Identified Gap

Although the available evidence is abundant, three gaps remain, and from them the present review is born. The first gap is fragmentation: technical analyses on waste characterization and diversion do not match socio-educational studies on knowledge, attitudes, and behavior. That is why the environmental culture of recycling, a phenomenon that combines cognition, affect, behavior, and governance, is not fully theorized (Manfredi et al., 2021; Vergani, 2024).

Second, empirical production is concentrated in high-income social contexts or in Asian and European countries, while Latin American and, in particular, Ecuadorian evidence is scarce and dispersed, frequently published in regional journals and with limited conceptual integration (Garabiza et al., 2021; Gonzales et al., 2023; Silva Jaramillo et al., 2024). The third gap is methodological: there are few syntheses that apply an explicit integrative method to bring together quantitative, qualitative and mixed studies and propose ways that can be carried out in a specific university in the global South.

Rationale and Objective

The relevance of this review is based on three considerations: at the scientific level, the fragmentation between technical research on residues and socio-educational research on knowledge, attitudes and behaviors calls for an integrative synthesis that the integrative review method is able to offer, by admitting evidence of heterogeneous designs within the same analytical framework.

At the regional level, the scarcity and dispersion of Ibero-American and, in particular, Ecuadorian evidence, justify a deliberate effort to incorporate it and put it in dialogue with international production, so that the resulting guidelines are culturally relevant and not a mere transfer of foreign models. At the institutional level, the University of Guayaquil does not start from scratch, it has a national regulatory framework, made up of the Organic Environmental Code, Ministerial Agreement 061 and the National Strategy for Inclusive Circular Economy, which calls for evidence-based interventions, to which this review seeks to respond.

Therefore, the general objective of this work is to synthesize recent scientific evidence on environmental education and culture strategies that promote solid waste recycling in higher education institutions, in order to support pedagogical and institutional guidelines applicable to the University of Guayaquil.

Four specific objectives guide this synthesis, the first characterizing environmental knowledge as a condition of recycling behavior. The second examines how attitudes and values mediate between that knowledge and practice. The third weighs the effectiveness of the documented pedagogical and institutional strategies. The fourth tracks the barriers and sociocultural facilitators that decide whether intention translates into behavior.

Behind these objectives beats a fundamental purpose: to articulate the five analytical categories and put Ibero-American and Ecuadorian evidence in dialogue with international evidence, to build a bridge between technical and socio-educational research and offer the Guayaquil university community an empirical base with which to move towards a sustained recycling culture.

Materials and methods

Study design

The integrative literature review design was adopted, according to the method proposed by Whitemore and Knafl (2005) and updated by Dhollande et al. (2021). This design is the only one that allows the integration in a single synthesis of evidence from dissimilar methodological designs (experimental, observational, qualitative, mixed and theoretical). In this way, the environmental culture of recycling is addressed, which has been investigated from very different disciplinary traditions. The method has five stages, namely: identification of the problem, literature search, evaluation of the data, analysis of the data and presentation of the synthesis.

The classic systematic review encompasses studies within the same profile and adds their effects, a situation that is not the one that arises as they are studies of all kinds; in contrast, integrative seeks to understand the entire phenomenon. Therefore, as the topic analyzed is not a single discipline, but encompasses education, organizational culture and waste management, a search and screening was chosen with an exploratory protocol defined a priori, which is in line with an integrative and non-confirmatory synthesis.

Research Question

The PICO scheme (Population, phenomenon of Interest, Context) constitutes the appropriate framework when the review incorporates qualitative data; with it the integrative question was constructed: in higher education communities (Population), *how do environmental education and culture interventions (phenomenon of Interest) shape the knowledge, attitudes and practices of solid waste recycling (Context)?*

Search strategy

The search was carried out in multidisciplinary databases (Scopus, Web of Science, Crossref and SciELO); Google Scholar joined to contribute regional literature. A Boolean equation was used built on three conceptual blocks: ("environmental education" OR "sustainability education" OR "environmental awareness" OR "environmental culture" OR "environmental culture" OR "pro-environmental behavior") AND ("recycling" OR "solid waste" OR "waste separation" OR "circular economy" OR "recycling" OR "solid waste") AND ("university" OR "higher education" OR "campus" OR "college students" OR "higher education").

The search process report followed the recommendations of the PRISMA-S extension (Rethlefsen et al., 2021). The identification combined two complementary sources: a reference library previously curated by the researcher and the searches carried out in the aforementioned databases.

The time horizon was set at the period 2020-2026 for the empirical body, in order to privilege the most recent evidence, and publications in Spanish, English and Portuguese were admitted to capture Ibero-American production, frequently absent from the English-speaking indexes. The restriction on open access documents, adopted for criteria of transparency and reproducibility, guarantees that any reader can verify the sources that support the synthesis.

Eligibility Criteria

The screening considered empirical research, whether quantitative, qualitative or mixed, and also reviews. Both had to address education, culture, knowledge, attitudes or practices of recycling and solid waste management in higher education institutions, be published between 2020 and 2026, in Spanish, English or Portuguese, and in open access. Purely technical waste engineering works without a socio-educational component, those limited to hazardous laboratory waste, editorials without data and duplicates were left out.

The seminal texts that support the theoretical bases (Ajzen, 1991; Dunlap et al., 2000; Frick et al., 2004; Hungerford & Volk, 1990; Kollmuss & Agyeman, 2002) were integrated as conceptual anchors; Its validity is explained by its canonical value. For the construction of the empirical base, studies from the last five years were used; the previous texts remained only to substantiate the constructs. Additionally, the existence of each selected source was corroborated and the accuracy of the attributed data was validated through its digital object identifier (DOI); any reference that did not pass this check was discarded.

Data Selection and Extraction Process

An adaptation of the PRISMA 2020 protocol (Page et al., 2021) was applied for screening, developed in four phases: identification, screening by title and abstract, eligibility assessment by reading the full text, and final inclusion. Clarivate's EndNote bibliographic manager was used for the management of references and the control of duplicates. Finally, screening by title and abstract and recording of inclusion and exclusion decisions were carried out in Microsoft Excel spreadsheets, using the logic of Rayyan, a tool specialized in systematic reviews (Ouzzani et al., 2016).

From each included study, the following fields were extracted in a standardized analysis matrix: authorship, year, country, design, sample, analytical category, main finding and level of evidence, of the 312 records identified from the researcher's curated library added to that of database searches, 240 were excluded because they did not align with the socio-educational approach in higher education institutions. to form a corpus of 72 studies included in the synthesis, complemented with six seminal conceptual anchors and three Ecuadorian normative sources used for framing.

The screening by title and abstract and the subsequent reading of the full texts were carried out independently, the most frequent reasons for exclusion were the exclusively technical-engineering approach to waste management, the absence of a socio-educational component, the non-university nature of the context studied and the unavailability of the full text in open access. The selection process is summarized in Figure 1.

Figura 1. Flujo de selección de estudios (PRISMA 2020, adaptado a revisión integrativa)

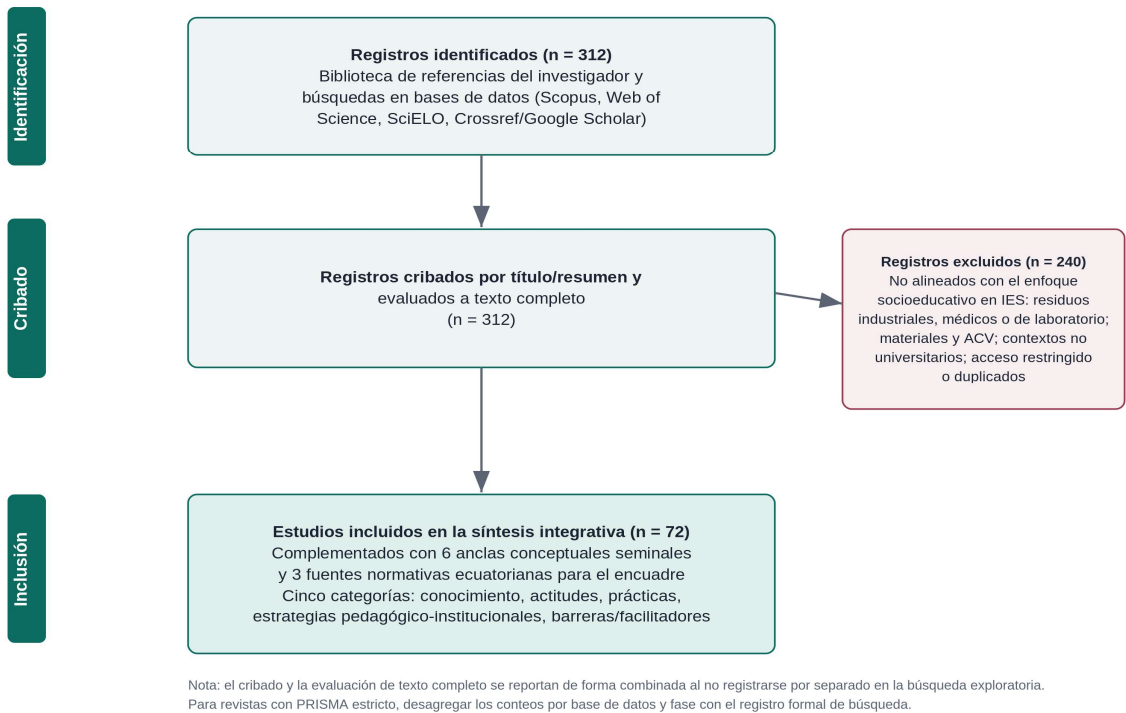


Figure 1. Study selection flow (PRISMA 2020, adapted to integrative review).

Quality assessment and synthesis

The methodological quality of the studies was assessed with the Mixed Methods Assessment Tool (MMAT) version 2018 (Hong et al., 2018), which is suitable for jointly appreciating quantitative, qualitative and mixed studies. Its application integrated the five design categories established by the tool: qualitative studies, randomized trials, non-randomized quantitative studies, descriptive quantitative studies, and mixed studies. The quality standards of each category were considered.

The synthesis process was based on thematic analysis and narrative synthesis, in accordance with the methodological standards for synthesis without meta-analysis (SWiM) of Campbell et al. (2020). The thematic analysis was developed in three sequential phases: first, the findings of each study were coded according to the five analytical categories; then the codes were grouped into convergent and divergent patterns; finally, an integrative narrative was constructed that puts evidence in front of the theoretical frameworks and the Ecuadorian context.

Results and Discussion

Based on the analysis of the corpus, the results were structured into the five analytical categories defined above. Table 1 groups the 72 studies analyzed, organized by author, country, research design, sample, category, and main finding. Next, a summary of each axis is presented, which confronts the convergent and divergent patterns identified in different studies and geographical contexts.

Table 1: Studies included in the integrative synthesis (n = 72)

Study (author, year)	Country	Design	Sample	Category	Main finding

Owojori et al. (2022)	South Africa	CAP Survey	University students (rural)	1 Knowledge	Knowledge is instrumental; The rural-urban divide persists.
Çebi & Arslan (2025)	Türkiye	Quasi-experimental	7th grade schoolchildren	1 Knowledge	Project-based education raises the level of knowledge about recycling.
Erhabor & Reis (2026)	Nigeria/Canada	Quasi-experimental	Future teachers univ.	1/2	Low-cost materials improve knowledge and attitudes.
Abdulghaffar & Williams (2021)	Saudi Arabia	Exploratory cross-sectional	University (KAU)	1 Knowledge	Institutional maturity is associated with greater environmental literacy.
Bennett & Alexandridis (2021)	USA	Review/Educational	Audience and students	1 Knowledge	Educating increases the fraction of plastic effectively recycled.
Al-Zohbi & Pilotti (2023)	Saudi Arabia	Case Study	430 university students	1/2	Fragmentary visions of sustainability in an oil-producing country.
Slotnick et al. (2023)	USA	Transversal	University students	1 Knowledge	Climate perceptions are associated with lower red meat intake.
Spinola (2023)	Portugal	Survey (NEP)	Univ. de Madeira	2 Attitudes	It measures environmental attitudes and challenges for environmental education.
Arslan et al. (2024)	Türkiye	Comparative (EAI)	320 university students	2 Attitudes	Outdoor sports are associated with better attitudes.
Alves et al. (2023)	Portugal	Survey	University students	2 Attitudes	Positive attitudes with a gap between attitude and action.
Pardal et al. (2025)	Portugal	Survey (20 HEIs)	400 students	2 Attitudes	Articulate knowledge, attitudes and circular behaviour.

Ferreira et al. (2023)	Portugal	Longitudinal mixto	Management students	2 Attitudes	Low knowledge despite favorable attitudes.
Lorincová & Osvaldová (2025)	Slovakia	Survey	Population	2 Attitudes	Sociodemographic factors shape attitudes and intentions.
Díaz Horna & Mejía (2025)	Peru	Experimental	Univ. (first cycle)	2 Attitudes	An experiential program strengthens conservation attitudes.
Hassooni et al. (2024)	UAE	CAP Survey	Population	2 Attitudes	Jointly evaluates knowledge, attitudes and practices.
Kyambade et al. (2024)	Uganda	Focus groups	22 students	2 Attitudes	Heterogeneity of attitudes towards climate change.
Muniandy et al. (2021)	Malaysia	TPB (survey)	252 academics	3 Internship	Attitude, norm, and perceived control predict behavior.
Abdul Waheed et al. (2023)	UAE	TPB (model)	Residents	3 Internship	Awareness, infrastructure and cost predict WEEE recycling.
Yang et al. (2021)	China	Survey	814 university students	3 Internship	Identifies factors of the willingness to separate waste.
Daoud et al. (2025)	UAE	Survey	University population	3 Internship	Socioeconomic factors condition behavior.
Guan et al. (2023)	China	Case Study	University students	3 Internship	Perceptions about plastic takeaway packaging.
Bang et al. (2025)	Vietnam	Survey	Students	3 Internship	Self-efficacy, incentives, and facilities explain the separation.
Ugulu (2026)	Türkiye	Scale Validation (Mixed)	University students	3 Internship	Validate a multidimensional scale of recycling behavior.
Dalu et al. (2023)	South Africa	Survey	Staff and students	3 Internship	Evaluate pro-environmental behavior towards plastics.
Zhang et al. (2021)	China	Mixed	AEC Students	3 Internship	Inconsistency between perceptions and behaviors of sustainability.

Alarinta et al. (2023)	Finland	Behavioral Monitoring	Households with univ.	3 Internship	Objective measurement of plastic packaging recycling.
Karakuyu & Carafil (2026)	Türkiye	Mixto pretest-posttest	32 schoolchildren	3/4	STEM-recycling education improves attitudes and behaviors.
Nagatomo (2024)	Taiwan	EDS (design-based)	N.A	3 Internship	Analyze consumer engagement in recycling.
Ayoub Moubareck (2022)	UAE	Quasi-experimental	90 university students	4 Strategies	Project-based learning outperforms the traditional classroom.
Iglesias-González et al. (2024)	Spain	Laboratory practice	Undergraduate students	4 Strategies	Introduce the circular economy in the laboratory.
Bohvalovs et al. (2025)	Latvia	System Dynamics	N.A	4 Strategies	Interactive tool for cleaner production.
Of Ugly (2026)	Italy	Educational framework	90,000 students	4 Strategies	Greenopoli: playful pedagogy for waste management.
Grillot & Martin (2026)	France	Serious play	Students	4 Strategies	CircAgri: experiencing circularity through role-playing.
Sulaiman et al. (2025)	Malaysia	Service-learning	32 univ. / 55 schoolchildren	4 Strategies	University students as trainers in recycling.
Kowasch (2022)	Austria	Qualitative (outputs)	Teacher training	4 Strategies	It incorporates CE, cradle-to-cradle and zero waste into teacher training.
Machado & Davim (2023)	Portugal	Review	N.A	4 Strategies	Curricular transformation and sustainable campus.
Manfredi et al. (2021)	USA	Pretest-posttest	University students	4 Strategies	Education raises awareness, but it is not enough for behavior.
Aedi (2024)	Indonesia	Review	N.A	4 Strategies	Green campus strategies through change management.

Pisuttu et al. (2024)	Italy	Case Study (Master's)	Postgraduate	4 Strategies	It integrates the EC in the management of MSW; public participation.
Al-Dmour (2023)	Jordan	Survey (PLS)	1,000 students	4 Strategies	Model the motivators of the green-smart campus.
Mansour (2024)	Iraq	Technical/Educational	Academic institutions	4 Strategies	Sustainable paper recycling techniques.
Craveiro et al. (2025)	Portugal	Case Study	IES	4 Strategies	Composting and awareness campaigns for circularity.
Jimu & Rennkamp (2024)	South Africa	Qualitative (governance)	University	4/5	Identify barriers and enablers of transitions.
Kountouris & Remoundou (2023)	Greece	Quasi-experimental causal	Cohorts	5 Barriers/eas y.	Causal evidence: Higher education increases recycling.
Oliveira & Proença (2025)	Portugal	Systematic review	N.A	5 Barriers/eas y.	Synthesize sustainable campus operations.
Vergani (2024)	Sweden	Review	N.A	1/5	HEIs as a microcosm of the circular economy.
Alazaiza et al. (2024)	Oman/Jordan	Bibliometric	N.A	5 Barriers/eas y.	Evolution of research in student consciousness.
Rodríguez-Guerreiro et al. (2024)	Spain	Review	IES (world)	1/5	Average rate 0.19 kg/day-person; management practices.
Sen et al. (2021)	Australia	Review	Universities	4/5	Sustainability and carbon neutrality strategies.
Owojori et al. (2020)	South Africa	Characterization	University	1/3	It characterizes the composition and the potential for recycling.
Budiardjo et al. (2021)	Indonesia	Case Study	Univ. (UNDIP)	3/4	Campus waste management strategies.
Stephan et al. (2020)	Australia	Flow analysis	Univ. of Melbourne	5 Barriers/eas y.	Material flows and circular economy on campus.
González et al. (2023)	Peru	Quantitative descriptive	244 university students	1/2	Diagnoses waste management and

					environmental culture.
Valencia-Ordóñez et al. (2025)	Mexico	Explanatory quantitative	Business Univ.	2/4	VARICA model of environmental culture.
Barboza-Contreras & Soto-López (2021)	Colombia	Action research	Primary school children	4 Strategies	Didactic strategies for environmental culture.
Muñoz Ramírez (2025)	Colombia	Quantitative	Schoolchildren 4th-5th	4 Strategies	Pedagogical strategies for environmental culture.
Piarpuezan et al. (2023)	Colombia	Action research	Schoolchildren (Awá)	4 Strategies	Pedagogical strategies in the indigenous community.
Cirimarco & De Oliveira (2022)	Brazil	Conceptual model	N.A	4 Strategies	Socio-environmental education based on the circular economy.
Carvalho & Cruz (2025)	Brazil	Qualitative review	N.A	4 Strategies	Pedagogical approaches to EE through EC.
Silva-Jaramillo et al. (2024)	Ecuador	Educational proposal	University students	4 Strategies	Collaborative work to reduce the impact of waste.
Garabiza et al. (2021)	Ecuador	Case Study	N.A	4/5	Application of the circular economy model in Ecuador.
He lies the Building et al. (2025)	Mexico	Model	IES	5 Barriers/easy.	Environmental management model for HEIs.
Jiménez-Martínez & García-Barrios (2020)	Mexico	Case Study	Campus	4/5	Zero Waste University Programme as a Social Innovation.
Villalba & Useche (2021)	Venezuela	Methodological	Universities	5 Barriers/easy.	Construction of environmental management indicators.
Navarrete et al. (2020)	Chile	Reflection/methodology	Higher Education	4/5	Sustainable model of higher education.
Borges et al. (2024)	Brazil	Collection/guides	Private HEIs	5 Barriers/easy.	Guidelines for the management of WEEE.
Savi-Bortolotto et al. (2025)	Brazil	Case Study	Univ. (UFSC)	4/5	Successful selective collection initiative.

Gherhe et al. (2024)	Romania	Survey	Students	5 Barriers/eas y.	Waste generation and disposal practices.
Pérez-López et al. (2021)	Spain	Footprint calculation	University	5 Barriers/eas y.	Ecological footprint of university mobility.
Silva et al. (2024)	Portugal	Measurement	10,278 meals	5 Barriers/eas y.	Inadequacy of portions and waste in the dining room.
Du Rand et al. (2024)	South Africa	Systems theory	Food service	5 Barriers/eas y.	Prevention of food waste.
Meireles et al. (2022)	Brazil	Impact assessment	Univ. (UEPA)	5 Barriers/eas y.	Assesses the environmental impacts of solid waste.

Note. The codes in the Category column correspond to the five analytical categories: 1 = knowledge; 2 = attitudes and values; 3 = practices; 4 = pedagogical-institutional strategies; 5 = barriers and facilitators. When a study contributes to two categories, both codes are indicated separated by a bar (e.g., 1/2).

Environmental knowledge: necessary but insufficient foundation.

Environmental knowledge is a necessary condition for recycling behavior, although it is insufficient on its own. The experience of a tertiary institution in the rural sector of South Africa, documented by Owojori et al. (2022), confirmed that, although knowledge was a strategic resource for the resolution of the problem, the rural-urban divide slowed down its materialization in practice. This dynamic corroborates what was postulated by Frick et al. (2004), who, through their categorization of knowledge into systems, action, and effectiveness, laid the foundations for understanding that the effect of knowledge on behavior is selective and depends on the nature of the information.

The malleability of knowledge is evident in the light of contemporary educational practices: with project-based work, students learned more about recycling than with the traditional classroom (Çebi & Arslan, 2025). In addition, low-cost laboratory materials, conceived from Vygotsky's theory as cultural mediating tools, strengthened the knowledge and attitudes of future educators (Erhabor & Reis, 2026).

The lag in environmental education, so common among youth in the developing world, exacerbates deficiencies in waste management; this lag, however, can be corrected (Debrah et al., 2021). In parallel, institutional maturity goes hand in hand with greater environmental literacy (Abdulhaffar & Williams, 2021). Simultaneously educating and informing the community and students increases the proportion of waste effectively recycled (Bennett & Alexandridis, 2021). Despite these advances, the distribution of knowledge remains heterogeneous: fragmentary visions of sustainability persist (Al-Zohbi & Pilotti, 2023) together with situated perceptions that affect specific behaviors (Slotnick et al., 2023).

Attitudes and values: the affective mediation between knowing and acting.

Various studies establish that the affective component, made up of attitudes and values, acts as a bridge between the acquisition of knowledge and observable action. The revised scale of the New Ecological Paradigm (Dunlap et al., 2000) stands as the main reference tool for measuring environmental beliefs. Spínola (2023) applied this scale to students at the University of Madeira and drew two lessons: that working on attitudes is key to rebuilding people's relationship with the planet, and that the diagnosis reveals the local challenges of environmental education. In their analysis, Arslan et al. (2024) evaluated the influence of outdoor physical activity on the environmental attitudes of 320 students and found differences that they attribute to interaction with the natural environment.

When addressing the circular economy, studies in the Ibero-American context reveal a persistent gap between discourse and practice. Although students manifest favorable attitudes, they incur inconsistencies when

executing concrete actions (Alves et al., 2023; Pardal et al., 2025); in certain cases, a positive attitude comes to coexist with little knowledge (Ferreira et al., 2023).

In Latin America, the VARICA model assesses the environmental culture of university business students (Valencia-Ordóñez et al., 2025), and waste management and environmental culture in Peruvian university students have been diagnosed together (Gonzales et al., 2023). This tension admits intervention: an experiential program strengthened conservation attitudes in a Peruvian university (Díaz Horna & Mejía Mejía, 2025). The measurement of attitudes has also been refined in different latitudes (Hassooni et al., 2024; Kyambade et al., 2024; Lorincová & Osvaldová, 2025). Overall, the affective component is both universal in its importance and specific in its cultural determinants.

Recycling practices and behavior: from purpose to observable behavior.

The third axis concentrates the evidence on effective separation and recycling practices, interpreted mostly through the Theory of Planned Behavior (Ajzen, 1991). In this regard, Muniandy et al. (2021) demonstrated, through the analysis of 252 Malaysian academics, that both attitude and subjective norm and perceived behavioral control are determining factors in behavior aimed at sustainable waste management.

The application of the model to e-waste recycling in the United Arab Emirates was developed by Abdul Waheed et al. (2023), who added environmental awareness, infrastructural support, and cost as new predictors. Their findings support the notion that recycling behavior arises from the interaction between the individual's intrinsic predispositions and situational factors.

The situated evidence offered by campus-scale case studies shows that socioeconomic and attitudinal determinants (Daoud et al., 2025; Yang et al., 2021), coupled with perceptions of plastic packaging (Guan et al., 2023), directly influence the decision to separate waste.

Metric rigor in this field was consolidated through the validation of a multidimensional instrument of responsible recycling behavior (Ugulu, 2026). Several studies have documented both the pro-environmental behavior in the face of plastic management (Dalu et al., 2023) and the dissonance between the perceptions and real behaviors of architecture, engineering, and construction students. This group is strategic due to its direct impact on the industry with the highest waste generation (Zhang et al., 2021). The analysis of material flows compensates for the limitations of self-reports by providing objective behavioral indicators (Alarinta et al., 2023). Finally, recycling-based STEM educational interventions show a positive impact on students' environmental attitudes and practices (Karakuyu & Karafil, 2026; Nagatomo, 2024).

Pedagogical and institutional strategies: intervening to transform

The fourth axis represents the articulating core of this review, as it groups together those interventions aimed at modifying knowledge, attitudes and practices. This approach is based on the postulates of Hungerford and Volk (1990) regarding the variables of environmental behavior change. Recent evidence, on the other hand, materializes this theoretical framework through three different modalities.

The first modality is curricular integration, within which Ayoub Moubareck (2022) evaluated a composting project within a microbiology course and measured its impact compared to conventional pedagogy. In turn, Iglesias-Gonzalez et al. (2024) incorporated the principles of the circular economy and waste recovery in a laboratory practice with undergraduate students. Along the same lines, Bohvalovs et al. (2025) designed an interactive pedagogical tool for cleaner production, based on system dynamics.

The second modality is playful and experiential pedagogy; Within it, two key approaches stand out. First, the experience reported by De Feo (2026) mobilized more than 90,000 students by combining science and creativity to empower them. Second, the serious game CircAgri, developed by Grillot and Martin (2026), allows participants to explore circularity through role-playing. The third modality corresponds to service-learning: Sulaiman et al. (2025) documented an experience in which 32 university students served as retraining instructors for schoolchildren.

At the institutional level, the literature evidences the need to link the educational process with campus governance. Approaches such as the circular economy, cradle-to-cradle principle, and zero waste can be integrated into teacher education (Kowasch, 2022). At the same time, the adequacy of curricula and the development of sustainable campuses are consolidated as strategic pillars for the modernization of higher education (Machado & Davim, 2023).

This axis reveals a crucial limitation, as Manfredi et al. (2021) point out: the development of awareness through environmental education does not guarantee, by itself, an alteration in the individual's habits. Hence, it is necessary to couple it with the management of institutional change (Aedi, 2024). It is also essential to promote initiatives that link environmental education and the circular economy, including at the postgraduate level (Pisuttu et al., 2024; Silva Jaramillo et al., 2024). On the other hand, a group of interventions is oriented towards the modification of the culture and institutional image (Al-Dmour, 2023; Craveiro et al., 2025; Mansour, 2024), while others focus on the governance of sustainability transitions (Jimu & Rennkamp, 2024).

A series of action research studies shows the feasibility of adapting these strategies to basic education, which is thus consolidated as a fundamental space to promote environmental culture (Barboza-Contreras & Soto-López, 2021; Cirimarcó & De Oliveira, 2022; Muñoz Ramírez, 2025; Piarpuezan et al., 2023). At this level, the circular economy model has been implemented as an eco-pedagogical strategy that familiarizes students early with recycling practices (Carvalho & Cruz, 2025).

Barriers and sociocultural facilitators.

The fifth axis categorizes the variables that condition the passage from intention to action. Kollmuss and Agyeman's (2002) model of the value-action gap provides a theoretical framework for understanding why favorable disposition toward a cause does not always translate into tangible behaviors. Regarding facilitating factors, Kountouris and Remoundou (2023) presented causal evidence when employing educational reforms in Greece as an exogenous variation. Their findings show that higher education increases recycling at home and makes university education a structural facilitator of pro-environmental behavior.

When examining the recent literature, the convergence between two syntheses stands out: that of Oliveira and Proença (2025) on sustainable campus operations and that of Vergani (2024). Their findings identify three structural barriers: insufficient infrastructure, fragmentation of governance, and weak institutionalization. Bibliometric studies complement the current panorama: while Alazaiza et al. (2024) examine the evolution of research on student awareness, Rodríguez-Guerreiro et al. (2024) analyze management practices. Together, both works delimit both the advances and the existing gaps in the discipline.

Regional evidence, on the other hand, shows that barriers and enablers depend to a large extent on the institutional particularities of each country. This is corroborated by research in the European context (Gherhe et al., 2024) and in Latin America, with the cases of Brazil (Borges et al., 2024; Savi-Bortolotto et al., 2025), Mexico (Herrera Godina et al., 2025; Jiménez-Martínez & García-Barrios, 2020), Chile (Navarrete et al., 2020) and Venezuela (Villalba & Useche, 2021). This contextual dependence underlines the need to formulate situated diagnoses prior to any intervention.

These situated diagnostics reveal that the particular components of campus metabolism operate in a dual way: they are both barriers and opportunities. Perez-Lopez et al. (2021) evaluated the ecological footprint derived from mobility at the University of A Coruña as an initial phase for the formulation of reduction policies. Silva et al. (2024) measured, in 10,278 meals from a Portuguese university canteen, the inadequacy of the portions served and food waste.

Du Rand et al. (2024) applied systems theory to food waste prevention in a university food service. Meireles et al. (2022), in turn, evaluated the environmental impacts of solid waste in a Brazilian university, in dialogue with the National Solid Waste Policy. All these cases show that detecting technical and socio-institutional obstacles in time is essential to design more effective waste management strategies in the university environment.

Main finding

The literature review indicates that the environmental culture of recycling in higher education institutions acts as an emergent property. This construct emerges from the joint action of three interdependent dimensions: cognitive (environmental knowledge), affective (attitudes and values) and structural (infrastructure and governance); none of them, isolated, is sufficient to produce it.

The mere acquisition of knowledge represents an essential starting point, but not a guarantee. Attitude serves as a link between cognition and action, while the effectiveness of pedagogical strategies depends directly on the institutional context. This integrative view transcends the fragmentation that was denounced in the introduction and offers a structured scheme to understand the heterogeneity of the literature reviewed.

Comparison with the literature and explanatory mechanisms

The evidence obtained validates and refines the postulates of the classical theoretical models. The limitation of isolated knowledge is aligned with the typology proposed by Frick et al. (2004). On the other hand, the gap between attitude and action, which persists throughout the corpus, is understood through the model of Kollmuss and Agyeman (2002), which attributes this disconnection to internal and external factors. Finally, from the Theory of Planned Behavior (Ajzen, 1991), the role of perceived behavioral control explains why the intention to recycle lacks practical viability in the absence of adequate infrastructure, such as differentiated containers and collection centers.

The evidence indicates, as Manfredi et al. (2021) have already warned, that the policies with the greatest impact are those that go beyond purely informational measures and integrate them with experiential approaches and structural modifications in university governance. In a complementary way, the findings of Kountouris and Remoundou (2023) indicate that the active intervention of universities in the promotion of an environmental culture enhances an effect that higher education itself exerts underlying.

The joint action of the three dimensions responds to three mechanisms. The first is cognitive: behavior is activated with knowledge of action and effectiveness, rather than with factual information alone. For this reason, interventions based on learning by doing (projects, laboratory practices and serious games) are more effective than classic expository teaching (Çebi & Arslan, 2025; Erhabor & Reis, 2026; Grillot & Martin, 2026; Iglesias-González et al., 2024).

The second mechanism is of an affective-normative nature; that is, the intention is mediated by pro-environmental attitudes and social norms, but it is diminished when the social and institutional environment does not accompany. This dynamic explains the constant discrepancy between favorable dispositions and materialized actions (Alves et al., 2023; Ferreira et al., 2023; Pardalet al., 2025).

The third mechanism has a structural basis; that is, perceived behavioral control, highly dependent on the institutional environment (infrastructure and governance), defines whether the intention finally leads to a concrete act. Consequently, material investment and institutional coordination are not secondary elements, but fundamental prerequisites for behavior development (Abdul Waheed et al., 2023; Muniandy et al., 2021; Oliveira & Proença, 2025; Vergani, 2024). In summary, the results show that interventions with the greatest impact require a multidimensional and simultaneous approach, as opposed to actions that are limited to a single dimension.

Implications for the University of Guayaquil

Based on the synthesis, it is imperative to establish for the University of Guayaquil five guidelines that are consistent with the national regulatory framework (National Assembly of Ecuador, 2017; Ecuador, 2021). The sensible thing to do is to start with a baseline diagnosis that characterizes, quantitatively and qualitatively, the generation and composition of waste by faculty and by campus, following the logic of university characterization studies (Budihardjo et al., 2021; Owojori et al., 2022; Rodríguez-Guerreiro et al., 2024).

The absence of such a baseline compromises the verifiability of deviation targets and the subsequent evaluation of interventions. Therefore, the transversal curricular integration of environmental education is urgent to prevent sustainability from being relegated to isolated subjects. This should permeate the curricula of the different disciplines, based on previous practices that have incorporated recycling and the circular economy both in regular courses and in teacher training (Ayoub Moubareck, 2022; Iglesias-González et al., 2024; Kowasch, 2022).

Third, it is recommended to implement experiential and service-learning approaches to train students as active agents of change in their community (De Feo, 2026; Sulaiman et al., 2025). The fourth guideline consists of guaranteeing the infrastructure for separation at source through differentiated containers and collection centers. This is a basic material requirement, since without it the perceived behavioral control is low, which prevents the intention to recycle from landing in a real action (Ajzen, 1991; Daoud et al., 2025).

Environmental education is insufficient if it is not accompanied by the infrastructure and resources necessary for action. Consequently, the fifth guideline requires institutional governance of sustainability that brings together teaching, research, and campus operation. This framework must be governed by responsible policies and structures, in accordance with the environmental management models designed for HEIs (Herrera Godina et al., 2025; Jiménez-Martínez & García-Barrios, 2020; Sen et al., 2021), and to provide feedback on Ecuadorian experiences already documented (Garabiza et al., 2021; Silva Jaramillo et al., 2024). The five guidelines make up an interdependent ecosystem: the diagnosis is the basis for training, this has an impact on attitudes, while the infrastructure enables the conduct and governance sustains the viability of the process in the long term.

Limitations

The scope and restrictions of this review need to be recognized. The decision to limit the corpus to open access literature responds to criteria of transparency and reproducibility; However, this choice carries the risk of having excluded significant contributions available only under subscription. There is also a fundamental limitation: the integration of diverse designs makes it impossible to reduce the results to a unified metric and orients the approach to evidence towards a narrative reading. This process inherently involves an interpretation; to narrow it down, we set the categories in advance and contrast each study with the WMAT criteria.

We also recognize the existence of a possible selection bias. The integration of the library curated by the researcher with systematic searches in databases expanded the documentary scope, but it implied that risk. To mitigate this, explicit eligibility criteria and a unified coding protocol were applied for all studies. Finally, there is a limitation that restricts the applicability of the proposals: the scarcity of empirical evidence circumscribed to the Ecuadorian context. For this reason, various guidelines are based on analogies with nearby countries in Ibero-America, which requires a prudent interpretation when extrapolating these results to the reality of Guayaquil.

Future research

In order to guide future research, four priority lines are formulated. The first of them focuses on the execution of primary empirical studies in the Ecuadorian university context, with measurement tools already validated (the Ugulu scale, 2026, and the VARICA model of Valencia-Ordóñez et al., 2025), in order to measure the knowledge, attitudes and practices of their community, second, longitudinal and quasi-experimental designs that evaluate the sustained effect of educational interventions combined with infrastructural changes.

Third, research on the institutional governance mechanisms that allow university recycling initiatives to be scaled up and sustained over time, fourth, comparative studies between faculties and between public and private universities in Ecuador that allow contrasting the effect of different governance models and infrastructure endowment on recycling results, as well as cost-benefit economic evaluations that support decision-making.

Conclusion

This review gathered recent evidence on the environmental education and culture strategies that promote solid waste recycling in higher education, the picture that emerges is clear: the university recycling culture does not depend on an isolated factor, it is formed at the intersection of five planes, environmental knowledge, attitudes and values, the practices of separation, the pedagogical-institutional strategies and the conditions of infrastructure and governance, it is worth insisting on the nuance that runs through all the evidence, knowledge is necessary, but it is not enough; attitudes mediate behavior; and education performs at its best only when it is accompanied by structural changes on campus.

For the University of Guayaquil, this analysis is materialized in a structured planning that includes five fundamental actions: quantifying, as a baseline, the volume and typology of the waste generated, mainstreaming environmental education within the curricula, executing experiential learning dynamics in the university community, financing the adaptation of physical facilities and institutionalizing sustainability through governance responsible; a set of measures that is legally based on national legislation, while converging with the 2030 Agenda and its Sustainable Development Goals.

The fundamental value of this study lies in having combined two traditionally distant approaches (the technical and the socio-educational) through their application in a specific institutional context. The validity of the five axes and guidelines proposed goes beyond the case of Guayaquil; These can be hosted by other universities in the region, as long as they adapt to their institutional realities. After all, recycling practices go beyond simple logistical management: they represent a way for citizen training.

Statements

Conflict of interest. There is no conflict of interest to declare on the part of the author.

Financing. This research did not receive specific external funding.

Data availability. This review is based on previously published studies, duly cited and verified by their respective DOIs in the references section. Therefore, no new primary data were generated, although the analysis matrix and the documentary corpus are available for consultation upon reasonable request.

Bibliographic References

- Abdul Waheed, K., Singh, A., Siddiqua, A., El Gamal, M., & Laeequddin, M. (2023). E-Waste Recycling Behavior in the United Arab Emirates: Investigating the Roles of Environmental Consciousness, Cost, and Infrastructure Support. *Sustainability*, 15(19), 14365. <https://doi.org/10.3390/su151914365>
- Abdulghaffar, N. A., & Williams, I. D. (2021). Development of sustainable waste management in higher education institutions. *AIMS Environmental Science*, 8(3), 238–254. <https://doi.org/10.3934/environsci.2021016>
- Aedi, N. (2024). Strategies and Best Practices for Implementing Green Campus: A Change Management Reviews. *Journal of Ecohumanism*, 3(4), 2492–2502. <https://doi.org/10.62754/joe.v3i4.3771>
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/https://doi.org/10.1016/0749-5978(91)90020-T)
- Al-Dmour, H. (2023). Green-Smart University Campuses: The Mediating Role of Student Engagement in Enhancing Corporate Image. *Sage Open*, 13(4). <https://doi.org/10.1177/21582440231219591>
- Al-Zohbi, G., & Pilotti, M. A. E. (2023). Contradictions about Sustainability: A Case Study of College Students from Saudi Arabia. *Sustainability*, 15(4), 3483. <https://doi.org/10.3390/su15043483>
- Alarinta, J., Närvä, M., & Wirtanen, G. (2023). Recycling of Plastic Food Packages: A Case Study with Finnish University Students. *Recycling*, 8(1), 23. <https://doi.org/10.3390/recycling8010023>
- Alazaiza, M. Y. D., Alzghoul, T. M., Al Maskari, T., Amr, S. A., & Nassani, D. E. (2024). Analyzing the Evolution of Research on Student Awareness of Solid Waste Management in Higher Education Institutions: A Bibliometric Perspective. *Sustainability*, 16(13), 5422. <https://doi.org/10.3390/su16135422>
- Alves, M. N., Seixas, C., Castro, A., & Leitão, A. (2023). Promoting the Transition to a Circular Economy: A Study about Behaviour, Attitudes, and Knowledge by University Students in Portugal. *Sustainability*, 16(1), 343. <https://doi.org/10.3390/su16010343>
- Arslan, Y., Suveren, C., Unlu, C., & Ceviker, A. (2024). Does Participation in Outdoor Sports Affect Environmental Attitudes? A Research on University Students. *International Journal of Education in Mathematics, Science and Technology*, 12(3), 682–692. <https://doi.org/10.46328/ijemst.4239>
- National Assembly of Ecuador. (2017). *Organic Environmental Code (COA)*. National Assembly of Ecuador
- Ayoub Moubareck, C. (2022). The effectiveness of project-based learning on Emirati undergraduate students in a microbiology course. *Learning and Teaching in Higher Education: Gulf Perspectives*, 18(2), 95–106. <https://doi.org/10.1108/lthe-06-2021-0047>
- Barboza-Contreras, G., & Soto-López, L. (2021). Didactic strategies that generate an environmental culture of solid waste reduction in students. *Interdisciplinary Peer-Reviewed Journal Koinonia*, 7(2), 130–144. <https://doi.org/10.35381/r.k.v7i2.1848>
- Bennett, E. M., & Alexandridis, P. (2021). Informing the Public and Educating Students on Plastic Recycling. *Recycling*, 6(4), 69. <https://doi.org/10.3390/recycling6040069>
- Bohvalovs, G., Blumberga, A., Liberova, V., & Blumberga, D. (2025). Novel Interactive Learning Tool for Cleaner Production Studies: Case Study. *Environmental and Climate Technologies*, 29(1), 611–622. <https://doi.org/10.2478/rtuct-2025-0042>
- Borges, R. M., Zagui, G. S., Bortoletto-Santos, R., Ismail, I. A. L., Souza, M. T., Simão, L., & Carita, E. C. (2024). Data Collection and Elaboration of Guidelines for Waste Electrical and Electronic Equipment Management in Brazilian Private Higher Education Institutions. *Sustainability*, 16(24), 11091. <https://doi.org/10.3390/su162411091>
- Budihardjo, M. A., Humaira, N. G., Putri, S. A., Ramadan, B. S., Syafrudin, S., & Yohana, E. (2021). Sustainable

Solid Waste Management Strategies for Higher Education Institutions: Diponegoro University, Indonesia Case Study. *Sustainability*, 13(23), 13242. <https://doi.org/10.3390/su132313242>

Campbell, M., McKenzie, J. E., Sowden, A., Katikireddi, S. V., Brennan, S. E., Ellis, S., Hartmann-Boyce, J., Ryan, R., Shepperd, S., Thomas, J., Welch, V., & Thomson, H. (2020). Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. *BMJ*, l6890. <https://doi.org/10.1136/bmj.l6890>

Carvalho, K. J. B. d., & Cruz, G. A. d. S. (2025). Circular economy as a tool for Environmental Education in Basic Education. *Brazilian Journal of Environmental Education (RevBEA)*, 20(1), 389–404. <https://doi.org/10.34024/revbea.2025.v20.19332>

Çebi, H., & Arslan, M. (2025). The Effect of Project-Based Recycling Education on Students' Recycling Knowledge Levels. *Science Insights Education Frontiers*, 31(1), 4959–4976. <https://doi.org/10.15354/sief.25.or840>

Cirimarco, S. K. J. W., & DE OLIVEIRA, C. M. R. (2022). Socio-environmental education based on the circular economy. *Research in Environmental Education*. <https://doi.org/10.18675/2177-580x.2022-16346>

Craveiro, A. L., Santos, M. T., & Rodrigues, A. (2025). Implementing Composting and Awareness Campaigns in a Higher Education Institution to Promote Circularity. *Sustainability*, 17(18), 8446. <https://doi.org/10.3390/su17188446>

Dalu, M. T. B., Ngoben, B. S., & Dalu, T. (2023). Assessing Pro-Environmental Behaviour towards Plastics among Staff and Students at a South African University. *Sustainability*, 15(24), 16904. <https://doi.org/10.3390/su152416904>

Daoud, O. W., Ahmed, V., Alzaatreh, A., & Anane, C. (2025). The impact of socio-economic factors on recycling behavior and waste generation: Insights from a diverse university population in the UAE. *Cleaner Waste Systems*, 11, 100266. <https://doi.org/10.1016/j.clwas.2025.100266>

De Feo, G. (2026). Engaging Environmental Education for Sustainable Waste Management—The Greenopoli Education Framework. *Recycling*, 11(1), 2. <https://doi.org/10.3390/recycling11010002>

Debrah, J. K., Vidal, D. G., & Dinis, M. A. P. (2021). Raising Awareness on Solid Waste Management through Formal Education for Sustainability: A Developing Countries Evidence Review. *Recycling*, 6(1), 6. <https://doi.org/10.3390/recycling6010006>

Dhollande, S., Taylor, A., Meyer, S., & Scott, M. (2021). Conducting integrative reviews: a guide for novice nursing researchers. *Journal of Research in Nursing*, 26(7), 642–656. <https://doi.org/10.1177/1744987121997907>

Díaz Horna, Í. A., & Mejía Mejía, E. J. (2025). Experiential environmental education program to strengthen environmental conservation attitudes among first-year students at a private university in the north, 2020. *Environmental Research and Ecotoxicity*, 4, 159. <https://doi.org/10.56294/ere2025159>

Du Rand, G., Viljoen, A., & Lefadola, B. P. (2024). Tackling food waste in a university food service operation: a case study. *International Journal of Environment and Waste Management*. <https://doi.org/10.1504/ijewm.2024.10067390>

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. *Journal of Social Issues*, 56(3), 425–442. <https://doi.org/10.1111/0022-4537.00176>

Ecuador, G. d. (2021). *National Strategy for Inclusive Circular Economy (ENECI)*.

Erhabor, N. I., & Reis, G. (2026). Low-Cost Educational Materials and University Student Teachers' Recycling Knowledge and Attitudes: A Quasi-Experimental Study. *Education Sciences*, 16(2), 325. <https://doi.org/10.3390/educsci16020325>

Ferreira, B. M., Abrantes, J. L., Reis, M., & Brambilla, F. R. (2023). A Longitudinal Study on Sustainability Perceptions in Portugal. *Sustainability*, 15(7), 5893. <https://doi.org/10.3390/su15075893>

Ferronato, N., Guisbert Lizarazu, E. G., Gorritty Portillo, M. A., Moresco, L., Vassura, I., & Torretta, V. (2020). Application of a life cycle assessment for assessing municipal solid waste management systems in Bolivia in an international cooperation framework. *Waste Management & Research*, 38(1_suppl), 98–116. <https://doi.org/10.1177/0734242x20906250>

- Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behavior: exploring prevalence and structure in a representative sample. *Personality and Individual Differences*, 37(8), 1597–1613. <https://doi.org/https://doi.org/10.1016/j.paid.2004.02.015>
- Garabiza, B. R., Prudente, E. A., & Quinde, K. N. (2021). The application of the circular economy model in Ecuador: A case study. *Spaces*, 42(02), 222–237. <https://doi.org/10.48082/espacios-a21v42n02p17>
- Gherhe□, V., Dragomir, G.-M., Cernicova-Buca, M., & Palea, A. (2024). Enhancing Sustainability in University Campuses: A Study on Solid Waste Generation and Disposal Practices among Students in Politehnica University Timisoara, Romania. *Sustainability*, 16(16), 6866. <https://doi.org/10.3390/su16166866>
- Gonzales, J., Arbulú, C., Medina, C., & Reluz, O. (2023). Solid waste management for environmental culture in university students. *Maker - AIAPÆC*, 7(2), 24–38. <https://doi.org/10.26495/rch.v7i2.2517>
- Grillot, M., & Martin, G. (2026). Stimulating students' learning about circularity challenges in agriculture with the CircAgri educational serious game. *Journal of Cleaner Production*, 549, 147772. <https://doi.org/10.1016/j.jclepro.2026.147772>
- Guan, Y., Wei, F., Liu, S., Tan, Q., & Li, J. (2023). Consumer perceptions and behaviors toward take-out food plastic packaging reduction: A case study of college students in China. *Circular Economy*, 2(3), 100052. <https://doi.org/10.1016/j.cec.2023.100052>
- Hassooni, S. K., El-Tarabily, K. A., Abu-Elsaoud, A. M., & Al Raish, S. M. (2024). An Assessment of the Knowledge, Attitudes, and Practices Toward General Waste Segregation among the Population of the United Arab Emirates. *Sustainability*, 16(17), 7720. <https://doi.org/10.3390/su16177720>
- Herrera Godina, M. G., González Estevez, G., del Moral Trinidad, L. E., Silva Bañuelos, G., Vizcaíno-Quirarte, A. M., & Muñoz Valle, J. F. (2025). Proposal of an Environmental Management Model for Higher Education Institutions: Case Study From University Center for Health Sciences. *Environmental Quality Management*, 35(1). <https://doi.org/10.1002/tqem.70168>
- Hong, Q. N., Fàbregues, S., Bartlett, G., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information*, 34(4), 285–291. <https://doi.org/10.3233/efi-180221>
- Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. *The Journal of Environmental Education*, 21(3), 8–21. <https://doi.org/10.1080/00958964.1990.10753743>
- Iglesias-Gonzalez, N., Ramírez, P., & Lorenzo-Tallafigo, J. (2024). From a Hazardous Waste to a Commercial Product: Learning Circular Economy in the Chemistry Lab. *Journal of Chemical Education*, 101(8), 3485–3492. <https://doi.org/10.1021/acs.jchemed.4c00509>
- Jiménez-Martínez, N. M., & García-Barrios, R. (2020). The Zero Waste University Program in Mexico: A Model for Grassroots Innovations in Sustainability. *Sustainability*, 12(22), 9444. <https://doi.org/10.3390/su12229444>
- Jimu, T., & Rennkamp, B. (2024). Science to practice – networked governance of sustainability transitions in an African university. *International Journal of Sustainability in Higher Education*, 25(9), 19–39. <https://doi.org/10.1108/ijshe-07-2023-0317>
- Karakuyu, A., & Karafil, B. (2026). Recycling-Based STEM Education for Sustainability: Effects on Secondary School Students' STEAM Attitudes, Recycling Behaviours and Design Thinking Skills. *Sustainability*, 18(4), 1820. <https://doi.org/10.3390/su18041820>
- Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, 8(3), 239–260. <https://doi.org/10.1080/13504620220145401>
- Kountouris, Y., & Remoundou, K. (2023). Does higher education affect pro-environmental behavior? Evidence from household waste recycling in Greece. *Environmental Research Letters*, 18(8), 084017. <https://doi.org/10.1088/1748-9326/ace19a>
- Kowasch, M. (2022). Circular economy, cradle to cradle and zero waste frameworks in teacher education for sustainability. *International Journal of Sustainability in Higher Education*, 23(6), 1404–1425. <https://doi.org/10.1108/ijshe-10-2021-0428>

- Kyambade, M., Mugerwa, G. W., & Namatovu, A. (2024). Insights on climate change in a business university setting: a case of Environmental Management students. *Cogent Education*, 12(1). <https://doi.org/10.1080/2331186X.2024.2442192>
- Lorincová, S., & Osvaldová, M. (2025). Pro-Environmental Behavior and Attitudes Towards Recycling in Slovak Republic. *Recycling*, 10(4), 159. <https://doi.org/10.3390/recycling10040159>
- Machado, C. F., & Davim, J. P. (2023). Sustainability in the Modernization of Higher Education: Curricular Transformation and Sustainable Campus—A Literature Review. *Sustainability*, 15(11), 8615. <https://doi.org/10.3390/su15118615>
- Manfredi, L. R., Stokoe, M., Kelly, R., & Lee, S. (2021). Teaching Sustainable Responsibility through Informal Undergraduate Design Education. *Sustainability*, 13(15), 8378. <https://doi.org/10.3390/su13158378>
- Mansour, M. M. (2024). Using Sustainable Technique to Recycle Waste Paper in Academic Institutions. *Al-Bahir*, 5(1). <https://doi.org/10.55810/2313-0083.1069>
- Meireles, R. R., Piratoba Morales, G., Mesquita Pereira, F., Menezes Nascimento, M. M., Machado Duarte, J. P., Farias da Silva, D., Costa Hianes, A., Costa da Silva, F., Carrera Moraes, V. M., & Sousa Leal, M. V. (2022). Evaluation of Environmental Impacts of Solid Waste at the State University of Pará, Campus V - CCNT. *Revista Brasileira de Geografia Física*, 15(3), 1336–1351.
- Ministry of the Environment of Ecuador. (2015). *Ministerial Agreement 061: Reform of Book VI of the Unified Text of Secondary Legislation of the Ministry of the Environment*. Ministry of the Environment of Ecuador
- Muniandy, G., Anuar, M. M., Foster, B., Saputra, J., Johansyah, M. D., Khoa, T. T., & Ahmed, Z. U. (2021). Determinants of Sustainable Waste Management Behavior of Malaysian Academics. *Sustainability*, 13(8), 4424. <https://doi.org/10.3390/su13084424>
- Muñoz Ramírez, D. E. (2025). Pedagogical Strategies to Strengthen Environmental Culture in Relation to Solid Waste Pollution with 4th and 5th grade students at the Angulo Rural Mixed School. *Ciencia Latina Revista Científica Multidisciplinar*, 9(1), 639–658. https://doi.org/10.37811/cl_rcm.v9i1.15770
- Nagatomo, D. (2024). Research on Education for Sustainable Development with Design-Based Research by Employing Industry 4.0 Technologies for the Issue of Single-Use Plastic Waste in Taiwan. *Sustainability*, 16(22), 9832. <https://doi.org/10.3390/su16229832>
- Navarrete, C., Saldías, G., Carbonetti, M., Fierro, J. M., & Sandoval, D. (2020). Towards a Sustainable Model of Higher Education in the Araucanía Region, Chile. *IOP Conference Series: Earth and Environmental Science*, 503(1), 012057. <https://doi.org/10.1088/1755-1315/503/1/012057>
- Oliveira, M. C., & Proença, J. (2025). Sustainable Campus Operations in Higher Education Institutions: A Systematic Literature Review. *Sustainability*, 17(2), 607. <https://doi.org/10.3390/su17020607>
- Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systematic Reviews*, 5(1). <https://doi.org/10.1186/s13643-016-0384-4>
- Owojori, O., Edokpayi, J. N., Mulaudzi, R., & Odiyo, J. O. (2020). Characterisation, Recovery and Recycling Potential of Solid Waste in a University of a Developing Economy. *Sustainability*, 12(12), 5111. <https://doi.org/10.3390/su12125111>
- Owojori, O. M., Mulaudzi, R., & Edokpayi, J. N. (2022). Student's Knowledge, Attitude, and Perception (KAP) to Solid Waste Management: A Survey towards a More Circular Economy from a Rural-Based Tertiary Institution in South Africa. *Sustainability*, 14(3), 1310. <https://doi.org/10.3390/su14031310>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, n71. <https://doi.org/10.1136/bmj.n71>
- Pardal, A., Moreira, A., Galacho, C., Mateus, D., Viegas, L., Gaspar, M., Ribau Teixeira, M., Manteigas, V., & Dinis, M. A. P. (2025). From Knowledge to Action: How Portuguese Higher Education Students Engage with Circular Economy Principles. *Sustainability*, 17(7), 3279. <https://doi.org/10.3390/su17073279>
- Perez-Lopez, J.-B., Orro, A., & Novales, M. (2021). Environmental Impact of Mobility in Higher-Education Institutions: The Case of the Ecological Footprint at the University of A Coruña (Spain). *Sustainability*, 13(11),

6190. <https://doi.org/10.3390/su13116190>

Piarpuezan, V. R., Herley Jamioy, N., & Revelo Cuaspu, H. A. (2023). Pedagogical Strategies to Strengthen Environmental Culture in the Face of Solid Waste Pollution in Primary School Students of the Awá Indigenous Campus, La Brava. *Ciencia Latina Revista Científica Multidisciplinar*, 7(5), 3129–3146. https://doi.org/10.37811/cl_rcm.v7i5.7944

Pisuttu, C., Adducci, F., Arena, S., & Lorenzini, G. (2024). A Master's Course Can Emphasize Circular Economy in Municipal Solid Waste Management: Evidence from the University of Pisa. *Sustainability*, 16(5), 1966. <https://doi.org/10.3390/su16051966>

Rodríguez-Guerreiro, M.-J., Torrijos, V., & Soto, M. (2024). A Review of Waste Management in Higher Education Institutions: The Road to Zero Waste and Sustainability. *Environments*, 11(12), 293. <https://doi.org/10.3390/environments11120293>

Savi-Bortolotto, G. D., Pescador, A. C., Bortolotto, T., Sandi, C. G., de Oliveira, A. V., Mendes, M. R. P., Madruga, K. C. R., & da Silva Júnior, A. H. (2025). Fostering a Sustainable Campus: A Successful Selective Waste Collection Initiative in a Brazilian University. *Sustainability*, 17(14), 6377. <https://doi.org/10.3390/su17146377>

Sen, G., Chau, H.-W., Tariq, M. A. U. R., Muttill, N., & Ng, A. W. M. (2021). Achieving Sustainability and Carbon Neutrality in Higher Education Institutions: A Review. *Sustainability*, 14(1), 222. <https://doi.org/10.3390/su14010222>

Silva Jaramillo, A., Tandazo Cuenca, T., Lapo Calderón, B., & Carchi Tandazo, T. (2024). An educational proposal to reduce the environmental impact of urban solid waste generated by students. 2024, 9(2), 20. <https://doi.org/10.23857/pc.v9i2.6616>

Silva, S. S., Pereira, A. C., Marques, B., & Liz Martins, M. (2024). Inadequacy of Meals Served and Food Waste in a Portuguese University Canteen. *Sustainability*, 16(10), 4317. <https://doi.org/10.3390/su16104317>

Slotnick, M. J., Falbe, J., Cohen, J. F. W., Gearhardt, A. N., Wolfson, J. A., & Leung, C. W. (2023). Environmental and Climate Impact Perceptions in University Students: Sustainability Motivations and Perceptions Correspond With Lower Red Meat Intake. *Journal of the Academy of Nutrition and Dietetics*, 123(5), 740–750. <https://doi.org/10.1016/j.jand.2022.09.015>

Spínola, H. (2023). Environmental attitudes among students at the University of Madeira, Portugal. *International Journal of Development Education and Global Learning*, 15(1). <https://doi.org/10.14324/ijdegl.15.1.06>

Stephan, A., Muñoz, S., Healey, G., & Alcorn, J. (2020). Analysing material and embodied environmental flows of an Australian university — Towards a more circular economy. *Resources, Conservation and Recycling*, 155, 104632. <https://doi.org/10.1016/j.resconrec.2019.104632>

Sulaiman, S., Asmuni, S., Ismail, Z., Aminuddin, Z. M., Tuan, B., Tuan Badrol Hisham Tuan, Besar, & Ibnu, M. S. (2025). Service Learning in Environmental Education: University students facilitating waste recycling awareness among school children in Malaysia. *Environment-Behaviour Proceedings Journal*, 10(SI30), 63–68. <https://doi.org/10.21834/e-bpj.v10iSI30.6880>

Ugulu, I. (2026). Development and validation of the responsible recycling behavior scale: a multidimensional assessment of university students' recycling practices. *Environmental Research Communications*, 8(6), 065004. <https://doi.org/10.1088/2515-7620/ae7256>

Valencia-Ordóñez, D., Rivas-Tovar, L. A., & Cárdenas-Tapia, M. (2025). VARICA Model of Environmental Culture in University Business Students. *Revista Universidad y Empresa*, 27(48), 1–25. <https://doi.org/10.12804/revistas.urosario.edu.co/empresa/a.14340>

Vergani, F. (2024). Higher education institutions as a microcosm of the circular economy. *Journal of Cleaner Production*, 435, 140592. <https://doi.org/10.1016/j.jclepro.2024.140592>

Villalba, L., & Useche, E. (2021). Methodological approach for the construction of environmental management indicators in universities. *Cleaner Environmental Systems*, 2, 100016. <https://doi.org/10.1016/j.cesys.2021.100016>

Whittemore, R., & Knafl, K. (2005). The integrative review: updated methodology. *Journal of Advanced Nursing*, 52(5), 546–553. <https://doi.org/10.1111/j.1365-2648.2005.03621.x>

Yang, X., Chen, X., Xiao, X., Xi, H., & Liu, S. (2021). College Students' Willingness to Separate Municipal Waste and Its Influencing Factors: A Case Study in Chongqing, China. *Sustainability*, 13(22), 12914. <https://doi.org/10.3390/su132212914>

Zhang, Y., Xu, L., Wu, W., Gong, Z., Moud, H. I., & Luo, Z. (2021). Ascertaining the Inconsistency of AEC Students' Perceptions and Behaviors Regarding Sustainability by Mixed Methods. *International Journal of Environmental Research and Public Health*, 18(24), 13274. <https://doi.org/10.3390/ijerph182413274>