

## Review article

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## Environmental education, university management and society: an analysis of their relationships in the literature

Educación ambiental, gestión universitaria y sociedad: un análisis de sus relaciones en la literatura

Educação ambiental, gestão universitária e sociedade: uma análise de suas relações na literatura

### Abstract

**Introduction:** environmental education is a central axis for universities in a global context marked by environmental crises. **Objective:** to analyze the relationships between environmental education, university management, and society to identify trends and research lines that underpin a theoretical model. **Methodology:** a mixed-documentary review was conducted, combining bibliometric and qualitative analyses. The Scopus database (2014-2024) was used to identify disciplinary areas, keywords, and research lines. The qualitative analysis followed a thematic approach, focusing on the most relevant articles. **Results:** five main trends were identified: the integration of environmental education into university management, an interdisciplinary approach, societal engagement, the use of digital technologies, and impact assessment. These trends highlight the role of universities as key players in multi-helix models involving governments, industries, and communities. **Conclusion:** the study underscored the need for a theoretical model that integrates environmental education within a helix framework. This model should foster interdisciplinarity, citizen participation, and technological innovation, strengthening universities' role in building sustainable societies.

**Keywords:** environmental education, university management, helix models, multi-actor collaboration, sustainability

### Resumen

**Introducción:** la educación ambiental es un eje central para las universidades en un contexto global marcado por crisis ambientales. **Objetivo:** analizar las relaciones entre la educación ambiental, la gestión universitaria y la sociedad, con el objetivo de identificar tendencias y líneas de investigación que fundamenten un modelo teórico.



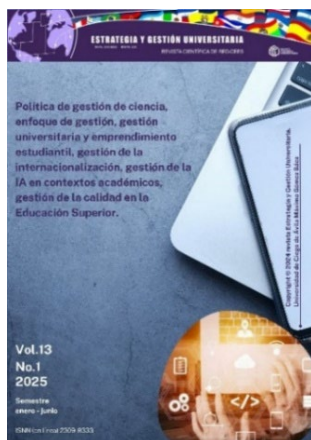
**Metodología:** se realizó una revisión documental mixta que combinó un análisis bibliométrico y otro cualitativo. Se utilizó la base de datos Scopus (2014-2024) para identificar áreas disciplinares, palabras clave y líneas de investigación. El análisis cualitativo siguió el enfoque temático, con dirección hacia los artículos más relevantes. **Resultados:** se identificaron cinco tendencias principales: la integración de la educación ambiental en la gestión universitaria, el enfoque interdisciplinario, la vinculación con la sociedad, el uso de tecnologías digitales y la evaluación de impactos. Estas tendencias destacan el papel de las universidades como articuladoras de modelos de hélice que involucran a gobiernos, industrias y comunidades. **Conclusión:** el estudio subrayó la necesidad de un modelo teórico que integre la educación ambiental en un marco de hélice. Este modelo debe promover la interdisciplinariedad, la participación ciudadana y la innovación tecnológica, fortaleciendo el rol de las universidades en la construcción de sociedades sostenibles.

**Palabras clave:** educación ambiental, gestión universitaria, modelos de hélice, colaboración multiactoral, sostenibilidad

### Resumo

**Introdução:** a educação ambiental é um eixo central para as universidades em um contexto global marcado por crises ambientais. **Objetivo:** analisar as relações entre educação ambiental, gestão universitária e sociedade, a fim de identificar tendências e linhas de pesquisa que fundamentem um modelo teórico. **Metodologia:** foi realizada uma revisão documental mista, combinando análises bibliométricas e qualitativas. A base de dados Scopus (2014-2024) foi utilizada para identificar áreas disciplinares, palavras-chave e linhas de pesquisa. A análise qualitativa seguiu uma abordagem temática, direcionada aos artigos mais relevantes. **Resultados:** foram identificadas cinco tendências principais: a integração da educação ambiental na gestão universitária, a abordagem interdisciplinar, a vinculação com a sociedade, o uso de tecnologias digitais e a avaliação de impactos. Essas tendências destacam o papel das universidades como articuladoras de modelos de hélice que envolvem governos, indústrias e comunidades. **Conclusão:** o estudo ressaltou a necessidade de um modelo teórico que integre a educação ambiental dentro de um quadro de hélice. Esse modelo deve promover a interdisciplinaridade, a participação cidadã e a inovação tecnológica, fortalecendo o papel das universidades na construção de sociedades sustentáveis.

**Palavras-chave:** educação ambiental, gestão universitária, modelos de hélice, colaboração multiatores, sustentabilidade



## Introduction

Environmental education constitutes a fundamental field of study and a system of action within a global context marked by unprecedented environmental challenges (Berchin et al., 2021). Climate change and climatic variability, biodiversity loss, pollution, and the overexploitation of natural resources have underscored the urgency of adopting comprehensive and collaborative approaches to address these issues (Wang et al., 2024). In this scenario, universities, through their numerous interconnections within the social fabric, have been called to play a leading role, not only as knowledge producers but also as agents of environmental transformation (Gardner et al., 2021). However, for their impact to be significant, it is necessary to understand how these institutions can articulate with other key actors, such as governments, industries, social organizations, and educational communities at prior levels, within a framework of collaboration that promotes sustainability (Vieira Nunes et al., 2021).

In recent decades, the academic literature has explored various dimensions of environmental education and its relationship with university management and society (Acosta Castellanos & Queiruga-Dios, 2022; Žalėnienė & Pereira, 2021). These studies highlight the importance of integrating sustainability into the strategic plans of higher education institutions, as well as the need to foster interdisciplinary and participatory approaches that involve multiple stakeholders (Leal Filho et al., 2021).

Nevertheless, it is vital to note that there are gaps in the understanding of how these efforts can be articulated in a systematic and effective manner. In this sense, the analysis of collaborative models, such as the helix model, becomes particularly relevant; this model is characterized by promoting interaction among academia, industry, government, and civil society (Bellandi et al., 2021).

This research emerged from the need to deepen these relationships and identify the main trends and lines of inquiry that have shaped the study of environmental education in the university context, aiming to achieve a broad representation of this field. Through a comprehensive document review, the goal was to synthesize the theoretical and practical advances, in order to provide a foundation for designing a theoretical model that integrates environmental education within a multi-stakeholder collaborative framework. Therefore, the aspiration is to develop a model that acts as a conceptual tool and guide for universities and other stakeholders in implementing sustainable and transformative strategies.

The relevance of this study lies in its contribution to the academic and practical debate regarding the role of universities in promoting sustainability. By identifying the most relevant trends and lines of research, it offers a clear perspective on existing advances and challenges, as well as opportunities to strengthen the articulation between environmental education, university management, and society. Ultimately, the analysis aims to serve as a basis for the design of policies, programs, and practices that foster collaboration among the different stakeholders involved.

## Methodology

The methodology was based on a mixed approach that combined techniques of document review and analyses both bibliometric and qualitative. This design allowed for a comprehensive exploration of the relationships between environmental education, university management, and society, drawing from the academic literature published between 2014 and 2024. The Scopus database was selected as the primary source due to its extensive coverage of scientific publications and its recognized rigor in indexing articles. Table 1 presents the general search strategy according to phases, drivers, and temporal aspects.

**Table 1**

*Search scheme by type of analysis*

| Phase                 | Strategy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bibliometric analysis | ( TITLE-ABS-KEY ( university AND management ) AND TITLE-ABS-KEY ( environmental AND education ) ) AND PUBYEAR > 2013 AND PUBYEAR < 2025                                                                                                                                                                                                                                                                                                                                                                                                            |
| Thematic Analysis     | ( TITLE-ABS-KEY ( university AND management ) AND TITLE-ABS-KEY ( environmental AND education ) ) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND ( LIMIT-TO ( EXACTKEYWORD , "Environmental Management" ) OR LIMIT-TO ( EXACTKEYWORD , "Sustainable Development" ) OR LIMIT-TO ( EXACTKEYWORD , "Higher Education" ) OR LIMIT-TO ( EXACTKEYWORD , "Environmental Education" ) OR LIMIT-TO ( EXACTKEYWORD , "Teaching" ) OR LIMIT-TO ( EXACTKEYWORD , "Environmental Protection" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( OA , "all" ) ) |

Source: Own elaboration.

In the bibliometric analysis phase, three key indicators guided the literature review. First, the main areas of disciplinary relationships were identified to understand how different fields of knowledge have approached the study topic.

Second, an analysis of the most recurrent keywords in the reviewed articles was conducted, helping to identify the central concepts that have dominated academic discussion over the past decade. Finally, the main lines of research, both consolidated and emerging, were determined, allowing for visualization of the thematic approaches that have predominated in the study of environmental education and its relationship with university management and society.

The qualitative analysis was carried out following the methodological proposals of Braun and Clarke (2022; 2023), specifically their thematic analysis approach. This process involved a detailed review of the most relevant articles identified in the bibliometric phase, but with a temporal restriction to the period 2020-2024 for greater relevance. Additionally, multiple filters were employed to refine the search, as presented in Table 1.

Those works that made significant contributions to the study topic based on their theoretical, methodological, or practical focus were selected. From this selection, an inductive coding of the data was conducted, allowing for the identification of patterns and recurring themes in the literature. These themes were organized and analyzed based on their relevance and their capacity to address the research questions posed.

The combination of these techniques provided a broad and deep view of the state of the art in the study topic. The bibliometric analysis offered a quantitative perspective that helped identify general trends and patterns in academic production, while the qualitative analysis allowed for a deeper exploration of the contents and meanings of the most relevant articles. This integration of methods strengthened the validity and reliability of the results, providing a solid foundation for the conclusions and recommendations presented in the article.

In concluding the methodological section, it is important to acknowledge significant limitations that should be recognized when contextualizing the findings. First, the reliance on the Scopus database, while justified based on coverage and rigor indicators, may have excluded relevant publications in other languages or in non-indexed journals, potentially affecting the representativeness of the results. Additionally, the analysis period (2014-2024) and the global focus of the study may have overlooked historical contributions or specific regional perspectives, limiting the diversity of contexts analyzed.

Furthermore, while the bibliometric analysis was useful for identifying general trends, it did not capture the quality or actual impact of the publications. The qualitative analysis, despite its rigor, was subject to the subjectivity inherent in the selection criteria and the coding process of the articles. Another significant limitation was the exclusion of grey literature (technical reports, theses, non-indexed books), which could have enriched the analysis with practical and applied perspectives.

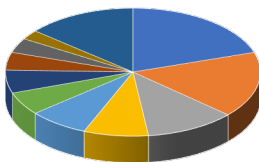
## Results and discussion

The analysis of the main areas of disciplinary relationships confirmed that the study of environmental education represents a complex space in terms of objectives, approaches, and positions, with a wide significance of educational and environmental processes. This analysis revealed a markedly interdisciplinary landscape, with the Social Sciences standing out as the predominant discipline, representing 20% of the publications (Figure 1).

**Figure 1**

*Main areas of disciplinary relationship*

### Percentage of publications



- Social Sciences
- Areas of engineering
- Medicine
- Energy
- Biological and agricultural sciences
- Others
- Environmental Sciences
- Computer science
- Business administration and management
- Earth Sciences
- Economic Sciences

Source: Compiled from Scopus.

This predominance reflects the importance of addressing environmental education from a social perspective, particularly focusing on aspects such as civic education, community participation, and the social responsibility of universities. It is argued that the social sciences provide theoretical and methodological frameworks to understand how institutions can integrate sustainability into their policies, curricula, and institutional practices, which constitutes the foundation for promoting an environmentally responsible culture.

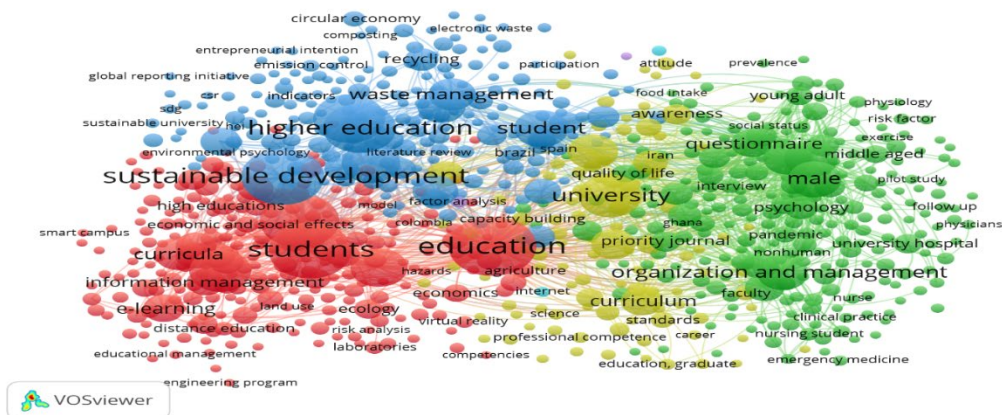
Secondly, Environmental Sciences (16.6%) were identified, occupying a central expected position as they provide essential technical and scientific knowledge to understand and address issues like climate change, natural resource conservation, and ecosystem management. This area is crucial for grounding environmental education in scientific evidence and for fostering the development of practical strategies that universities can implement on their campuses and in their communities (Fraisl et al., 2022).

Following these two disciplines, Engineering (11.4%) emerged, related to its contribution through technological solutions and practices for sustainability, such as efficient infrastructure design, waste management, and innovation in renewable energy. Additionally, Computer Sciences (8.2%) gained relevance over the last decade, particularly with the use of emerging technologies like artificial intelligence and big data—tools that allow for the analysis of large volumes of environmental data, optimize university management, and personalize teaching in environmental education (Himeur et al., 2022). Lastly, Medicine (7.6%) related to environmental education through topics such as public health, the impact of pollution on human health, and the promotion of sustainable lifestyles, highlighting the connection between human well-being and environmental protection (Henderson & Loreau,



The analysis of keywords revealed a total of 10,096 keywords, of which 776 were used for analysis based on their recurrence, specifically those with five or more co-occurrences. After the initial filtering process, the first three (human, humans, article) were removed to avoid distorting the most important lines. This procedure revealed a significant interconnection among the areas of environmental education, university management, and society, evidencing an interdisciplinary approach in the scientific literature (Figure 2).

Network map for all analyzed keywords

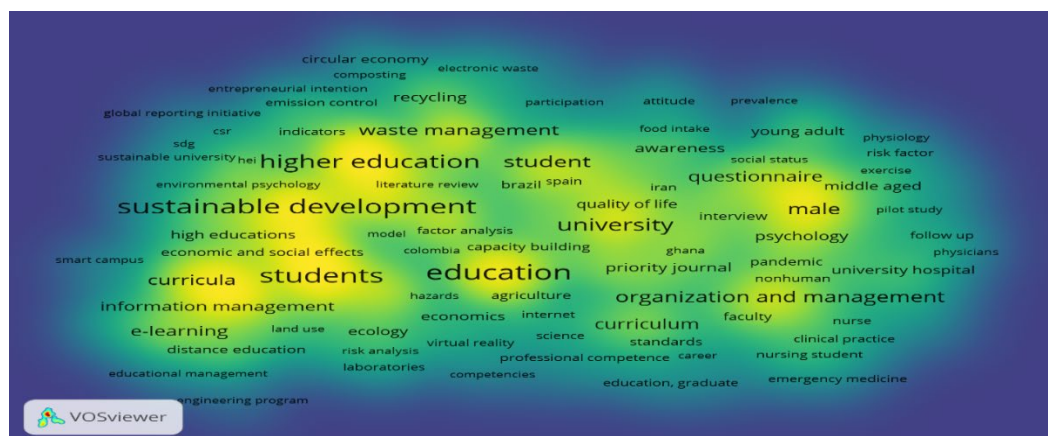


In the field of environmental education, terms such as “environmental education” (135 occurrences, 892 links) and “climate change” (86 occurrences, 795 links) stand out as central pillars, reflecting the importance of training on environmental issues and the urgency of addressing climate change within educational settings. Furthermore, concepts like “sustainability education” (17 occurrences, 107 links) and “education for sustainable development” (26 occurrences, 151 links) underline the growing integration of sustainability into academic curricula, suggesting progress toward building a holistic approach that transcends mere knowledge transmission to foster critical and proactive awareness of environmental challenges.

In the context of university management, the most relevant keywords, such as “higher education” (213 occurrences, 1503 links) and “project management” (48 occurrences, 343 links), indicate a growing interest in optimizing administrative and academic processes within higher education institutions (Figure 3). Terms like “university management” (8 occurrences, 31 links) and “educational management” (7 occurrences, 38 links) reflect the need to adopt efficient management models that allow universities to adapt to the demands of the 21st century (Figueiró et al., 2022). Additionally, the presence of “campus sustainability” (16 occurrences, 82 links) and “sustainable campus” (14 occurrences, 72 links) evidences efforts to transform university campuses into models of sustainability, integrating practices such as waste management, energy efficiency, and resource conservation (Anthony Jnr, 2021).

### Figure 3

### Term analysis by density



Source: Authors' own elaboration using data from Scopus and VOSviewer software.

Moreover, the analysis indicated that the relationship between university management and environmental education is strengthened through concepts such as “sustainability in higher education” (6 occurrences, 19 links) and “sustainable universities” (5 occurrences, 37 links), which highlight the adoption of sustainable policies and practices in educational institutions. These initiatives aim to reduce the environmental impact of universities and to train professionals capable of leading the transition toward sustainable development (Mokski et al., 2023). Additionally, the use of emerging technologies, such as artificial intelligence (14 occurrences, 144 links) and “big data” (16 occurrences, 150 links), was observed in both university management and environmental education, with their main joint applications including personalized learning, resource optimization, and large-scale environmental data analysis (Zhai et al., 2021).

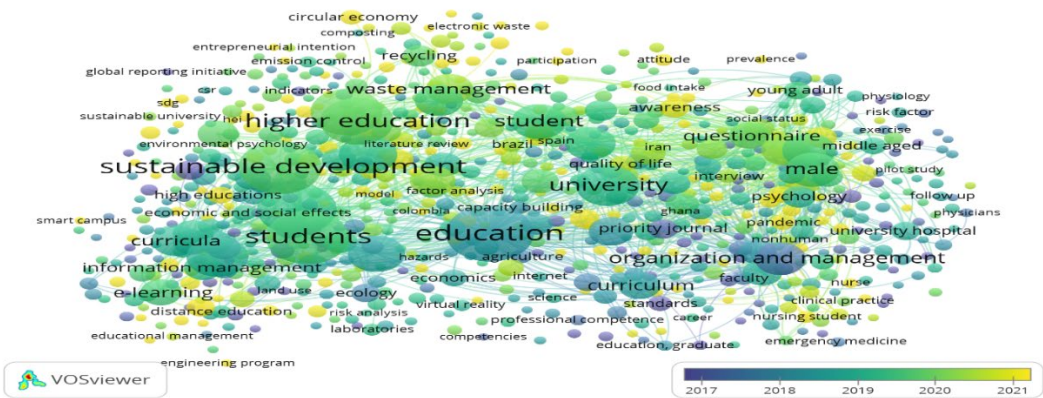
Regarding the relationship with society, keywords such as “social responsibility” (23 occurrences, 206 links) and “community engagement” (10 occurrences, 68 links) highlight the role of universities as agents of social change (M.



Ali et al., 2021). University social responsibility manifests in initiatives that promote community participation, social justice, and collective well-being, as reflected by terms like “university social responsibility” (12 occurrences, 68 links) and “community-based participatory research” (6 occurrences, 115 links). Furthermore, the connection between environmental education and public health is evidenced by keywords like “public health” (47 occurrences, 804 links), suggesting that universities can contribute to addressing environmental issues with direct implications for the health and well-being of communities (Pirchio et al., 2021).

From the triangulation of data and external sources, it was observed that the concept of “sustainable development” (275 occurrences, 2277 links) emerged as a transversal axis integrating the three thematic areas, emphasizing the importance of a systemic approach to addressing environmental, social, and economic challenges. This term reflects the mission of universities to prepare global citizens committed to sustainability, as well as their role as catalysts for innovation and social change. Along these lines, other emerging trends were contrasted, which can be observed temporally in Figure 4 and analyzed in the matrix presented in Table 2.

Figure 4  
Analysis of consolidated and emerging lines



Source: Authors’ own elaboration using data from Scopus and VOSviewer software.

Table 2  
Matrix of emerging trends analysis

| Emerging Trends                                          | Key Terms                                           | Analysis                                                                   | Future Opportunity                                            |
|----------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------------|
| Integration of artificial intelligence (AI) in education | Artificial intelligence (14 occurrences, 144 links) | AI is transforming education by enabling personalized learning, automating | Develop ethical and transparent AI models that enhance equity |

|                                                                           |                                                                                                                                                                       |                                                                                                                                                                                                                 |                                                                                                                                       |
|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
|                                                                           |                                                                                                                                                                       | administrative tasks, and predictive data analysis.                                                                                                                                                             | and inclusion in education.                                                                                                           |
| Education for sustainability and the Sustainable Development Goals (SDGs) | Sustainable development (275 occurrences, 2277 links), Sustainability education (17 occurrences, 107 links), Sustainable development goals (17 occurrences, 51 links) | Education for sustainability has gained relevance, especially in the context of the SDGs. Universities aim to adopt a more integrated approach to prepare global citizens committed to sustainable development. | Strengthen the integration of SDGs into university curricula and promote international collaborations to address global challenges.   |
| Immersive technologies (virtual and augmented reality)                    | Virtual reality (12 occurrences, 150 links)                                                                                                                           | Immersive technologies are used to create interactive and immersive learning experiences, particularly in environmental education, engineering, and medicine.                                                   | Explore the potential of these technologies to simulate complex scenarios and foster empathy towards environmental and social issues. |
| Big data and predictive analytics                                         | Big data (16 occurrences, 150 links), Data analysis (6 occurrences, 122 links)                                                                                        | The use of big data enables educational institutions to make evidence-based decisions, optimize resources, and personalize the learning experience.                                                             | Develop predictive analytics tools to anticipate student needs and improve retention and academic success.                            |
| Gamification and game-based learning                                      | Serious games (5 occurrences, 53 links)                                                                                                                               | Gamification is used to increase student engagement and promote active learning. Serious games are particularly useful for teaching complex concepts of sustainability and environmental management.            | Design educational games that address global issues such as climate change and social inequality.                                     |

|                                                |     |                                                                                                          |                                                                                                                                                                                                                  |                                                                                                                            |
|------------------------------------------------|-----|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Smart sustainable campuses                     | and | Smart campus (5 occurrences, 16 links), Campus sustainability (16 occurrences, 82 links)                 | University campuses are adopting technologies like the Internet of Things (IoT) and energy management systems to reduce their environmental footprint and improve operational efficiency.                        | Implement scalable technological solutions that enable universities to become sustainability models for their communities. |
| Hybrid and flexible education                  |     | Blended learning (12 occurrences, 59 links), Online learning (14 occurrences, 66 links)                  | The COVID-19 pandemic accelerated the adoption of hybrid education models, combining the best of in-person and online education. This trend will continue, offering greater flexibility and access to education. | Develop innovative pedagogical strategies that maximize the benefits of hybrid education.                                  |
| Interdisciplinary and collaborative approaches |     | Interdisciplinary approach (14 occurrences, 142 links), Collaborative learning (7 occurrences, 93 links) | The complexity of environmental and social challenges requires interdisciplinary approaches that integrate knowledge from various fields, such as social sciences, engineering, and environmental sciences.      | Foster collaboration between disciplines and sectors to develop innovative and sustainable solutions.                      |

Source: Compiled from Scopus.

Thematic analysis

The application of inclusion criteria aimed at refining the search strategy and ensuring a relevant sample resulted in the selection of a total of 13 articles. Table 3 presents the citation and details for each document.

Table 3

Matrix of analyzed studies

| No. | Research Summary                                                                                                                                                                                                                | Citation                        |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| 1   | The study analyzes the importance of green universities, examining their strengths and weaknesses, as well as student perceptions regarding environmental activities and initiatives.                                           | (E. B. Ali & Anufriev, 2020)    |
| 2   | The article discusses how green practices and initiatives contribute to achieving a sustainable university, noting how green human resource management can enhance sustainability.                                              | (Zahrani, 2024)                 |
| 3   | This article grounds environmental education in external settings as part of a risk management project, offering recommendations for similar experiences.                                                                       | (Beery, 2020)                   |
| 4   | The research highlights the importance of student management for the development of university students, noting how Civic Education can enhance student skills.                                                                 | (Hao, 2024)                     |
| 5   | The article presents a program aimed at improving environmental sustainability in universities, where participants showed increased environmental awareness and new sustainability rules were implemented.                      | (Gomera et al., 2021)           |
| 6   | This article analyzes the university as a social change agent, evaluating students' environmental awareness and emphasizing the importance of environmental education.                                                          | (Esteban Ibáñez et al., 2020)   |
| 7   | The research examines environmental education and educational activities from students' perspectives, based on expeditions conducted by a forestry corps, focusing on well-being, speed of travel, and program time management. | (Hayakawa & Sugiura, 2021)      |
| 8   | This study seeks to integrate all key sustainability elements to meet the Sustainable Development Goals, analyzing new social and economic dimensions and their importance.                                                     | (Greenland et al., 2023)        |
| 9   | The article examines the social responsibility of universities, its importance, and impact on society, analyzing the scientific production on this topic and its economic and sustainability impacts.                           | (Meseguer-Sánchez et al., 2020) |
| 10  | This research analyzes the role of universities in achieving quality, equitable, and inclusive education, as well as their role in incorporating environmental policies.                                                        | (Vallespín Pérez, 2022)         |
| 11  | This study examines how personal ideals and positions influence the willingness to engage in pro-environmental activities.                                                                                                      | (Juma-Michilena et al., 2023)   |
| 12  | The research analyzes student awareness regarding environmental education and the                                                                                                                                               | (Djirong et al., 2024)          |

|    |                                                                                                                                                                                              |                               |
|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
|    | use of green technologies in universities, highlighting the need for new practices for environmental protection.                                                                             |                               |
| 13 | The article analyzes the importance and effectiveness of university management, along with the influence of leadership on university management and the need for new models for improvement. | (Mattos et al., 2022)         |
| 14 | This research explores the green innovation capacity of university workers and its effective management, concluding that such innovation can enhance organizational climate.                 | (Bahmani et al., 2023)        |
| 15 | This article analyzes environmental education from the perspective of teachers, demonstrating how proper university management can improve education for sustainable development.            | (Zúñiga Sánchez et al., 2022) |

Source: Authors’ own elaboration.

In recent years, environmental education has gained prominence as a transversal axis in university management. Higher education institutions have integrated sustainable policies and practices into their strategic plans, not only as a response to social demands but also as a commitment to training professionals who are aware of their impact on the environment (Ferrer-Estévez & Chalmeta, 2021; Serafini et al., 2022). This trend reflects a paradigmatic shift in which universities assume an active role in promoting sustainability, both on their campuses and in surrounding communities.

Another notable trend is the interdisciplinary approach to environmental education, as universities have begun to encourage collaboration among faculties and departments to address environmental issues from multiple perspectives (Abo-Khalil, 2024). This approach has facilitated the creation of innovative academic programs that combine natural sciences, social sciences, and humanities, enriching students’ education and providing them with more holistic tools to face current environmental challenges.

The literature also indicates a growing interest in citizen participation and community engagement. Universities have developed outreach and community engagement projects aimed at raising awareness and training the population on environmental issues (Lindemann et al., 2022). These initiatives strengthen the link between academia and society while contributing to the development of more resilient communities committed to environmental stewardship.

Additionally, there has been an increased incorporation of digital technologies in environmental education (Alieksieienko et al., 2022). Universities have adopted virtual platforms, simulators, and augmented reality tools to complement the theoretical and practical training of students. This technological advancement has democratized access to environmental information and facilitated the creation of collaborative networks among institutions globally (Hajj-Hassan et al., 2024).

Lastly, the importance of evaluating and measuring the impact of environmental education initiatives in university management was highlighted. More institutions have implemented indicator systems to monitor the progress of their sustainable actions and ensure that these meet the established objectives (Elmassah et al., 2022). This approach has allowed for greater transparency and accountability, strengthening universities' credibility as agents of change in society.

### **Analysis of the importance of helix relationships**

The integration of environmental education into university management has proven to be a catalyst for articulating efforts across different sectors. From the helix model, which promotes interaction among academia, industry, government, and civil society, universities have emerged as key players in promoting sustainability (Shyiramunda & Van Den Bersselaar, 2024). Their capacity to produce knowledge, innovate, and train critical professionals positions them as a bridge among diverse stakeholders. For example, many universities have established partnerships with local governments to implement recycling programs or with companies to develop clean technologies, demonstrating their role as facilitators of initiatives that benefit society as a whole.

The interdisciplinary approach in environmental education has enabled universities to tackle complex problems from an integrated perspective, which is essential for collaboration in helix models (Pereira et al., 2023). By fostering the participation of experts in natural sciences, social sciences, engineering, and humanities, universities not only enrich their own academic offerings but also facilitate the creation of innovative solutions tailored to the needs of each context. This approach has been crucial for projects requiring the involvement of multiple stakeholders, such as ecosystem restoration or the implementation of environmental public policies, where the university acts as a space for dialogue and co-creation.

Another prominent trend is the engagement with society, which has strengthened the role of universities as agents of social change (Morawska-Jancelewicz, 2022). Through outreach projects and citizen participation, higher education institutions have successfully raised awareness in entire communities about the importance of sustainability (Leal Filho et al., 2023). These actions not only generate a direct impact on people's quality of life but also prepare new generations to assume responsible leadership in their environments. Students participating in these projects gain practical skills and develop a critical consciousness that enables them to actively contribute to building more just and sustainable societies.

The incorporation of digital technologies in environmental education has expanded universities' reach in their interactions with other stakeholders (Oliveira & De Souza, 2021). Virtual platforms and technological tools have facilitated the creation of collaborative networks that transcend geographical boundaries. This has allowed universities to share knowledge and best practices with governments, non-governmental organizations, and other educational institutions, thereby strengthening their role as hubs of innovation and knowledge dissemination. Additionally, these technologies have prepared students to face the challenges of a digitalized world, where information and collaboration are essential.



Finally, the evaluation and measurement of the impact of environmental education initiatives have reinforced the credibility of universities as reliable actors in helix models (Zakaria et al., 2023). By implementing indicator systems and accountability measures, institutions have demonstrated their commitment to transparency and continuous improvement. This has facilitated the creation of strategic alliances with other stakeholders, who view universities as trustworthy partners for driving long-term projects (Borah et al., 2023). Furthermore, this approach has enabled universities to adjust their programs and strategies to respond more effectively to the needs of society and the planet.

## Conclusions

The analysis of the literature shows that environmental education is solidifying as an essential component in university management, not just as an academic subject, but as a guiding principle that informs their policies, practices, and projects. Higher education institutions demonstrate an increasing commitment to sustainability by integrating interdisciplinary approaches and promoting participation from diverse stakeholders in the search for solutions to environmental challenges. This active role of universities positions them as key agents in training aware professionals and promoting significant social and environmental changes.

The study emphasizes the relevance of helix models, which foster interaction among academia, industry, government, and civil society, to address environmental challenges in a comprehensive manner. Universities emerge as facilitators of these collaborative networks, enabling the exchange of knowledge, resources, and experiences. This articulation not only expands the impact of environmental education initiatives but also strengthens the link between theory and practice, allowing academic advancements to translate into concrete and sustainable actions.

The review of trends and lines of inquiry allows for the identification of key elements for designing a theoretical model that integrates environmental education within a multi-stakeholder collaborative framework. This model should consider interdisciplinarity, citizen participation, the use of innovative technologies, and continuous impact evaluation as fundamental pillars. Additionally, it should be flexible and adaptable to local contexts, promoting the inclusion of diverse social and educational actors. Constructing this model represents a crucial step in strengthening the role of universities in promoting sustainability and preparing new generations to face the environmental challenges of the 21st century.

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### Declaration of author responsibility

**Yairelys Nancy Huerta Gómez 1:** Conceptualization, Data Curation, Formal Analysis, Research, Methodology, Resources, Software, Supervision, Validation/Verification, Visualization, Writing/original draft and Writing, review and editing.

**Rolando Gustavo Gómez Meza 2:** Conceptualization, Data Curation, Formal Analysis, Research, Methodology, Validation/Verification, Visualization, Writing/Original Draft and Writing.

**Carlos Alberto Severiche Sierra 3:** Conceptualization, Data curation, Formal analysis, Research, Methodology, Validation/Verification, Visualization, Writing/original draft and Writing, review and editing.

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