frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 15 August 2024
DOI 10.3389/feduc.2024.1306522

OPEN ACCESS

EDITED BY
Gladys Sunzuma,
Bindura University of Science Education, Zimbabwe

REVIEWED BY
Irina Safitri Zen,
International Islamic University Malaysia, Malaysia
Inga Grinfelde,
Latvia University of Agriculture, Latvia

*CORRESPONDENCE
Pedro Mauricio Acosta-Castellanos
✉ pedro.acosta@usantoto.edu.co

RECEIVED 10 April 2024
ACCEPTED 05 August 2024
PUBLISHED 15 August 2024

CITATION
Acosta-Castellanos PM, Queiruga-Dios A and Camargo-Mariño JA (2024) Environmental education for sustainable development in engineering education in Colombia.
Front. Educ. 9:1306522.
doi: 10.3389/feduc.2024.1306522

Environmental education for sustainable development in engineering education in Colombia

Pedro Mauricio Acosta-Castellanos[1]*, Araceli Queiruga-Dios[2] and Julian A. Camargo-Mariño[1]

[1]División de Ingenierías y Arquitectura, Universidad Santo Tomás, Tunja, Colombia, [2]Department of Applied Mathematics, Higher Technical School of Industrial Engineering, Universidad de Salamanca, Bejar, Spain

Introduction: Environmental education (EE) has been extensively studied and promoted in Latin America, particularly in Colombia, through educational policies and regulations at all educational stages. While EE is well-established, Education for Sustainable Development (ESD) is gaining increasing global importance, especially with the advent of the Sustainable Development Goals (SDGs). Despite this, there remains a lack of knowledge, application, and research of ESD within engineering programs in higher education. This study aims to explore these gaps and assess the acceptance of ESD compared to EE among engineering students in Colombia.

Methods: A survey was conducted among 406 engineering students from eight universities in Colombia that offer undergraduate engineering programs. The survey included both Likert scale questions and open-ended questions. The objective was to measure students' knowledge and perception of ESD, identify the roots of EE within engineering programs, and evaluate the progressive integration of ESD in these curricula.

Results: The results revealed the deep-rooted presence of EE in Colombian engineering programs and a gradual incorporation of ESD into these curricula. However, significant gaps were identified. The majority of students demonstrated limited knowledge of ESD and Sustainable Development (SD). Furthermore, there was a noticeable lack of academic areas or subjects within the engineering curriculum that specifically promote the knowledge and application of ESD. Students' responses also highlighted the unusual convergence between EE, a traditionally conservationist field, and ESD, which is more development-oriented.

Discussion: This research identifies several critical challenges faced by engineering education in Colombia. The limited awareness of ESD among students suggests a need for enhanced integration of sustainable development concepts within engineering curricula. The lack of academic subjects dedicated to ESD further exacerbates this issue. Based on these findings, a transition strategy is proposed to bridge the gap between EE and ESD in Colombian higher education. This strategy aims to provide a smoother transition and better integration of sustainable development principles within engineering programs, ultimately supporting the development of engineers equipped to address contemporary global challenges.

KEYWORDS

environmental education, education for sustainable development, higher education, critical reflection, engineering education, Colombia, sustainability

1 Introduction

Environmental education (EE) and Education for Sustainable Development (ESD) are usually perceived as opposing pigeonholed models. However, both seek to address the environmental problems generated by human action and ensure a sustainable environment for future generations through education (Molano Niño and Herrera Romero, 2014; Murray et al., 2014; Flórez-Yepes, 2015; Rendón López et al., 2018b; Marouli and Duroy, 2019).

EE has a broad historical background, as it has been used since the 1970s in different educational fields (UNESCO-UNEP, 1993). The purpose of EE is to protect the environment (Marouli, 2021), using awareness and contact with nature to create effective connections (Ernst and Theimer, 2011; Stern et al., 2021). EE was originally conceived as an answer to environmental problems caused by economic and industrial development, consumerism, and urban growth, among others (Dlouhá and Pospíšilová, 2018). However, EE had to change to adapt to new generations and the tools of our digitalized world, which have hindered people's contact and awareness with nature. Awareness in EE can be defined as the synergy between people, communities, and organizations of all kinds with the environment (Mastrángelo et al., 2019; Ardoin and Bowers, 2020). This synergy seeks that people move from passive discourse to action; that is, it aims to change the way human beings act toward the environment to protect and preserve it (Suárez-Perales et al., 2021). EE has a holistic nature that seeks to create an impact through literacy around environmental problems, educating people from early childhood to adulthood (Ardoin and Bowers, 2020). EE is commonly found in schools from early childhood to higher education (Shi and Liu, 2011).

Meanwhile, ESD has a less recorded history; it was not until 1990 to 2000 that the first research references used this name (Acosta Castellanos and Queiruga-Dios, 2022). This trend gained strength thanks to the so-called Decade of ESD, which was promoted by the United Nations (UN) (Filho et al., 2015). ESD aims to educate people and society at large about Sustainable Development (SD). SD originated in 1987 as part of the document "Our common future" (UN Secretary-General, 1987); from that moment until now, little has changed in its definition. However, the measurement instruments and tools to achieve SD have been updated and promoted by most of the UN member states. In this sense, in 2014, the Sustainable Development Goals (SDGs) were introduced (Biasi et al., 2019). These objectives are aimed at achieving a balance between the social, economic, and environmental factors of the SD philosophy (Kopnina, 2014; Ekpiken and Ukpabio, 2015). There are 17 goals within the SDGs. Objective number four, "quality education," aims to achieve that "all students acquire the knowledge and skills necessary to promote SD" (Elmassah et al., 2021). Likewise, ESD has been said to be the most precise tool to educate society to achieve the SDGs (Dlouhá and Pospíšilová, 2018).

Therefore, this research started by identifying EE and ESD as two different concepts, both in their foundation or philosophy and in their final purpose. This differentiation is based on the statement that EE is focused on environmental protection and is far from the global perspective of trade and anthropocentrism. On the other hand, ESD moves away from conservationism or environmental protectionism and is anthropocentric (McKeown and Hopkins, 2003; Stevenson, 2006; Nomura, 2009). In order to contextualize these two currents in Colombia, the historical connections and influence of EE or ESD on engineering curricula in Colombia will be outlined below.

1.1 EE in Colombia

EE in Colombia is contemporary to its global implementation in the 1970s; precisely in 1974, EE is explicitly mentioned within an official text in the "National Code of Natural Resources" in chapter 2 of this state policy document. In 1993, the Colombian environmental policy was created through Law 99, which also structured the National Environmental System (SINA). This law repeatedly mentions EE as the way to promote the protection of natural resources in Colombia (Flórez-Yepes, 2015; Pita-Morales, 2016), and establishes EE as a compulsory subject within primary and secondary education. Finally, in 1994, Decree 1743 was enacted, formalizing and promoting the Environmental Education Project at all levels of formal education. Likewise, EE is included in different sections of Law 115 (Flórez-Yepes, 2015; Mejía-Cáceres et al., 2020; Pérez Vásquez, 2020).

Within these official documents are the School Environmental Projects, which are pedagogical projects that are well-grounded in the theory of EE. Therefore, they promote knowledge about the environment and its protection, encouraging participation and interaction among the actors of the educational center: students, teachers, and the community (Mora-Ortiz, 2015).

Perhaps the most significant EE document in Colombia is the "Environmental Education Policy" issued by the Ministry of National Education of Colombia in 2002. This document has become the guide for the application of EE in primary, secondary, higher education, and non-formal education centers. This document encourages and regulates educational institutions to promote EE; likewise, it urges both private companies and public institutions to promote EE. Said policy aims to foster a change in people's attitudes toward the environment within the values promoted by democracy (Badillo Mendoza, 2012; Calderon-Madero et al., 2019).

Colombia has had difficulties in implementing the (EE) as a general initiative despite having a national policy on the matter. Studies suggest that engineering curricula only incorporate 5% of topics related to EE (Acosta Castellanos et al., 2020a,b). Therefore, the government requires universities to include EE in the training of their students. Based on this overview, we can see the political affinity of EE in Colombia and its public institutions.

1.2 ESD in Colombia

Contrary to EE, no norm or policy explicitly mentions the promotion or application of ESD in formal or non-formal education in Colombia. However, an important milestone in this country is the reference within the Supreme Decree within the 1991 Constitution of Colombia. Article 80 of this document states that "*The State will plan the management and use of natural resources to guarantee its sustainable development, conservation, restoration or replacement*" (República de Colombia, 1991).

Colombia has had a slow implementation of ESD at all educational levels. This is even more noticeable in Higher Education Institutions (HEI) since it is expected that their vision of education will be reflected in high-impact research publications; in this sense, previous research has shown the inclination and preference for research. On the other hand, compared to EE, ESD research is low both in Colombia and in Latin America (Cavalcanti-Bandos et al., 2021; Acosta Castellanos and Queiruga-Dios, 2022). ESD in HEI has limited research and diagnostic projects, with low applicability, since its relevance does not seem to transcend to the decision-making bodies or the political institutions (Hernández-Diaz et al., 2021). The lack of clarification of ESD within public policy documents does not mean that there is a refusal to achieve SD. In this sense, the SINA was created to comply with the provisions of the Constitution referring to SD. Therefore, ESD is not officially present in Colombia, but different areas, especially research, have addressed its inclusion in all education levels (Callejas Restrepo et al., 2017; Cavalcanti-Bandos et al., 2021; Acosta-Castellanos and Queiruga-Dios, 2022). In this regard, Colombia provides examples highlighting the promotion of sustainable development. For instance, Law 1,549 of 2012 sets forth guidelines to enhance environmental education by orienting it toward sustainable development. Article 5 states: "Article 5. Establishment of political instruments. It is the responsibility of territorial entities and the Regional Autonomous Corporations for Sustainable Development to: (a) Develop technical-political instruments that contextualize the policy and adapt it to the needs of building an environmental culture for sustainable development…" (Congreso de la República, 2012).

The importance of incorporating ESD in Colombia lies in the country's limited achievements in SD through the SDGs. In the latest metrics regarding the achievement of the SDGs, Colombia ranked number 9 among 12 countries in Latin America and the Caribbean (CODS, 2020). However, despite not having a policy that encourages ESD, efforts have been made to integrate it through research at a formal education level (Penalosa Farfan and Paucar-Caceres, 2018; Builes-Vélez et al., 2024).

The objective of this study was to substantiate some research questions formulated within a project that focuses on the inclusion of ESD in engineering. Previous publications were focused on systematic literature reviews, in which it was identified that Latin America in general, and Colombia in particular, have a greater inclination toward EE than ESD (Acosta Castellanos and Queiruga-Dios, 2022). Therefore, this study seeks to answer the following question: Is the training in engineering degrees in Colombia oriented toward EE and not ESD? Moreover, the following question regarding curricular aspects was also formulated: Can ESD OR SD knowledge be evidenced in the training of engineers in Colombia?

At the same time, this research aims to generate momentum and evidence for the need to keep the engineering curriculum up to date on ESD as a tool to train future engineers on SD. In the discussion, we will propose a specific approach according to the authors' perspective on the most viable way to achieve an impact in sustainability through engineering education.

2 Methodology

The study was based on a survey sent to all universities in Colombia that offer engineering programs, receiving responses from 406 students from eight universities. The majority of respondents were between 19 and 21 years old, with the distribution of students by year of study ranging from the first to the fifth year, the latter being the most represented. The participating universities included both public and private institutions, providing a diverse sample. The engineering degrees that participated in the survey included Civil Engineering, Environmental Engineering, Industrial Engineering, Systems Engineering, Electronic Engineering, Mechanical Engineering, Chemical Engineering, Agricultural Engineering, Petroleum Engineering, and Electrical Engineering, reflecting the breadth of the engineering field in Colombia. The survey included 14 questions, 12 of which were Likert scale questions and two open-ended questions, designed to measure students' knowledge and opinions on Environmental Education (EE) and Education for Sustainable Development (ESD).

The Likert scale questions were formulated in pairs, directly comparing EE and ESD concepts, with responses ranging from "strongly disagree" to "strongly agree." Additionally, two open-ended questions aimed to identify the training spaces where students believed they had acquired knowledge about EE and ESD. The reliability of the questionnaire was validated with a Cronbach's alpha coefficient of 0.8, indicating high internal consistency. Despite the limitations in sample size, the results provide valuable insights into the perceptions of engineering students regarding EE and ESD in their academic training.

2.1 Sample

A survey was sent to all universities offering engineering programs in Colombia ($n = 120$), and a response was obtained from ($n = 406$) students from 8 universities, namely, Santo Tomás University (USTA), Pedagogical and Technological University of Colombia (UPTC), Minuto de Dios University (MINUTO), National University of Colombia (UNAL), La Salle University (Salle), Juan De Castellanos University (JDC), University del Bosque (Bosque) and the University of the Sabana (De la Sabana). Figure 1 shows the distribution of the engineering degrees that participated in the survey. The mean age of the students who answered the survey was 21 years, with their ages ranging from 15 to 56 years. The most common age range in the responses was between 19 and 21 years. The distribution of the years is: 1st year ($n = 51$), 2nd year ($n = 31$), 3rd year ($n = 68$), 4th year ($n = 105$), and 5th year ($n = 151$). It is important to remember that engineering in Colombia is generally a 5-year degree.

2.2 Survey

2.2.1 Likert Scale questions

The questions were formulated using an affirmative statement and the Likert Scale, as can be seen in Table 1. This scale is widely used to determine the respondents' opinions or degree of knowledge (Likert, 1932; Bowling and Windsor, 2008). It formulates an introductory statement for respondents to rate on a scale (Kaplan et al., 2021). In this case, a scale of 1 to 4 was used, where 1 was "strongly disagree" and 4 was "strongly agree" In addition, the response options were presented horizontally to avoid extreme response tendencies (Weijters et al., 2020).

Fourteen questions were formulated, of which 12 were Likert Scale questions and two were open-ended questions. The initial questions were formulated in such a way that 7 were related to EE and 7 to ESD. The questionnaire was designed in pairs, that is, each question about EE had a mirror question about ESD. Table 1, lists the 12 questions that were formulated using statements and the Likert Scale.

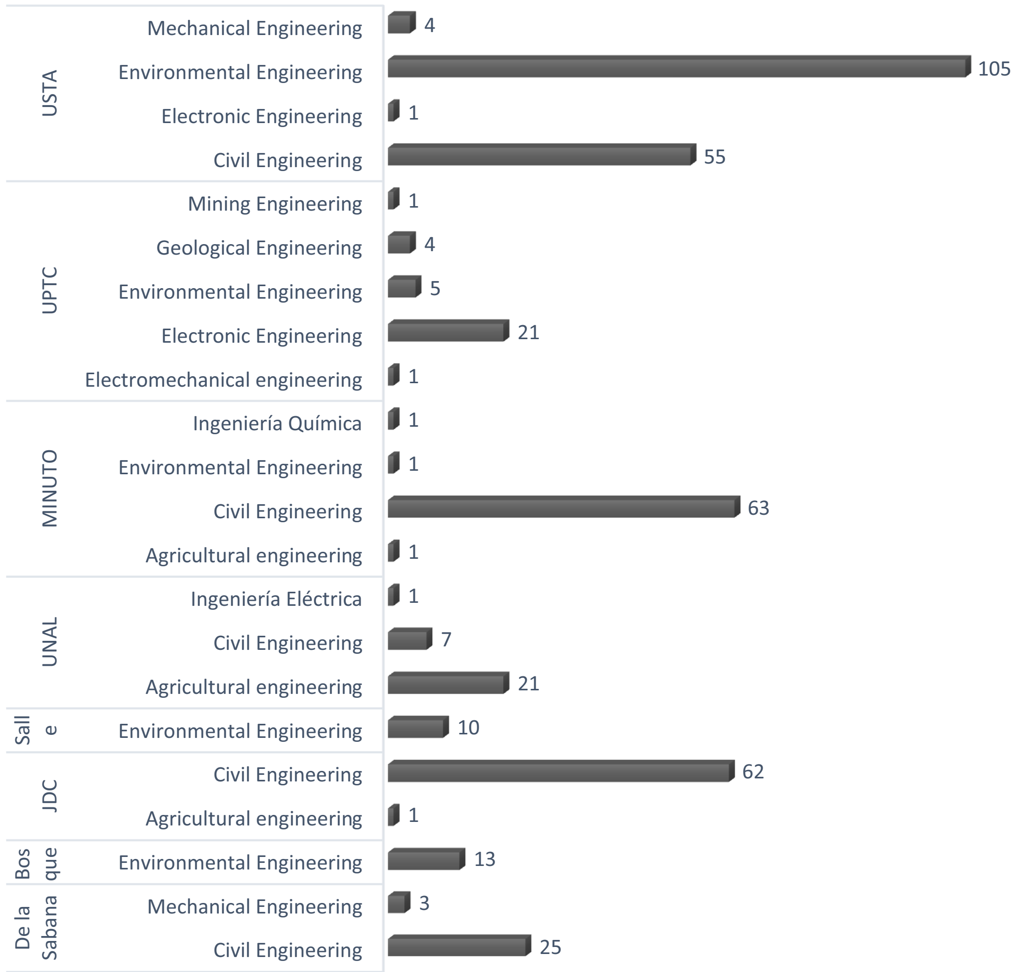

FIGURE 1
Students surveyed according to degree and university.

2.2.2 Open-ended questions

In order to broaden the source of data collection, two open-ended questions were added to complement the scope of the Likert Scale questions. In addition, open-ended questions allow additional data to be obtained and analyzed jointly with the structured questions (Jaeger and Rasmussen, 2021; Nikulchev et al., 2021). The open-ended questions asked were the following:

> *Q13: Mention the training spaces or areas in which you consider that you have obtained knowledge and tools for the application of EE.*
>
> *Q14: Mention the training spaces or areas in which you consider that you have obtained knowledge and tools for the application of ESD.*

The survey was administered in two sections so that the respondent could differentiate between the EE and ESD questions. Therefore, questions Q1 to Q6 and Q13 were answered in a separate section corresponding to EE. Once answered, a new section corresponding to the remaining ESD questions was administered, that is, Q7 to Q12 and Q14.

2.3 Survey reliability

An internal consistency analysis was applied using Cronbach's alpha coefficient. This coefficient measures the internal consistency of the correlation between the items that make up a scale (Cortina, 1993). The value of the coefficient varies between 0 and 1. An instrument is considered valid if the coefficient is more significant than 0.7 and less than 0.9 (Oviedo and Campo-Arias, 2005). For this survey, the calculated value of the coefficient was 0.8. On the other hand, the instrument's reliability was previously tested in two groups, where the applied instrument was refined and improved.

On the other hand, a Chi-Square analysis was performed to evaluate the relationship between the specialization or type of engineering and higher education institutions. The Chi-Square Test of Independence is commonly used to determine if there is a significant

TABLE 1 Likert Scale questionnaire.

Q1	I know that Environmental Education (EE) is essential in the engineering degree I am studying.	Q7	I know that Education for Sustainable Development (ESD) is essential in the engineering degree I am studying.
Q2	It is clear to me that Environmental Education (EE) is important in engineering, as it gives me a broad understanding of the role I play as an engineer in nature's transformation and conservation.	Q8	I am clear that Education for Sustainable Development (ESD) provides me with the knowledge to constructively confront the challenges humanity faces (population growth, life cycles, biodiversity, overexploitation, among others).
Q3	I have received classes, workshops, or specific training within the subjects of my studies that involve concepts or actions related to Environmental Education (EE).	Q9	I have received classes, workshops, or specific training within the subjects of my studies that involve concepts or actions related to Education for Sustainable Development (ESD).
Q4	My teachers need to have more training to promote Environmental Education (EE) within the subjects that I have already taken.	Q10	My teachers need to have more training to promote the principles of sustainable development within the subjects I have already taken.
Q5	The curriculum and syllabus of the engineering subjects that I am studying ensure I have the theoretical and practical knowledge needed to promote Environmental Education (EE).	Q11	The syllabus and syllabus of the engineering subjects I am studying ensure I have the theoretical and practical knowledge needed to promote sustainable development.
Q6	I think it is essential to propose a subject focused on Environmental Education (EE) within the curriculum of the engineering degree that I am studying.	Q12	I think it is essential to propose a subject focused on Education for Sustainable Development (ESD) within the curriculum of the engineering degree that I am studying.

association between two categorical variables. The results indicated a significant relationship between these variables ($\chi^2 = 825.62$, $p < 0.001$, degrees of freedom = 63). The observed and expected frequencies suggest that the distribution of engineering specializations varies significantly according to the university.

2.4 Limitations

It is important to acknowledge the inherent limitations of this type of research. The most evident limitation was the size of the population, as we anticipated greater participation from universities and their students. The instrument's application procedure was conducted transparently, by sending it to the rectors of the universities listed in the directory of the Colombian Ministry of National Education website. It was also sent to the deans' offices of the engineering departments at each university.

Although we received responses from 406 students across 8 universities, this number may not be representative of the entire population of engineering students in Colombia. A larger sample size would increase the statistical power of the study and enhance the ability to detect significant differences. The higher concentration of responses from 4th and 5th-year students could also bias the results toward greater exposure to Environmental Education (EE) and Education for Sustainable Development (ESD).

Additionally, it should be noted that universities with fewer than 10 responses were excluded to ensure greater reliability of the results.

3 Results

As mentioned above, the questions were tailored to be able to compare them against a parallel question. Thus, the results are shown in pairs to be able to contrast them. Tables 2, 3 show the number of responses and the statistics (mean, mode and standard deviation) corresponding to them. En la tabla 2, se muestran las preguntas realizadas con escala liket, cada pregunta representada con una letra Q y que se muestra en detalle en la tabla 1. A su vez se muestran el total de respuestas por escala Likert. Por su parte la tabla 3, muestra los porcentajes que representa cada opción de respuesta.

Concerning Q1 and Q7, it can be observed that most students are clear about the definition and purpose of EE and ESD. In both cases, the responses of the Likert scale option 4, "Strongly agree," are close to 80% and options 1 and 2 are the least common.

Q2 and Q8, respectively, denote a greater inclination of students to EE, although there is a low 17.5% difference between them. This answer reflects the importance students give to EE or ESD within their training.

A similar trend is observed in Q3 and Q9. In this case, results reflect that it is not common for engineering subjects to receive instruction or training on EE or ESD. According to the students' responses, they receive more training in EE than in ESD. In this same sense, questions Q4 and Q10 indicate that professors require more significant preparation in EE and ESD, even more so in ESD. This need is made evident if the Likert scale response options 4 and 3 are added together, corresponding to 79.8% for EE and 86.7% for ESD.

On the other hand, the results of Q5 and Q11 show higher percentages than the content of the subjects that ensured knowledge about EE and SD. It should also be noted that a significant number of respondents chose Likert scale options 1 and 2. This is due to the lack of curricular content regarding EE and ESD; in the case of EE, the sum of the two options in the lower range is 24.6, and 21.9% or ESD.

Finally, questions Q6 and Q12 reflect a clear interest in improving the curriculum by incorporating subjects dedicated exclusively to EE and ESD. In this sense, option 4 represents 66.3 and 60.8% of the responses, respectively.

Figure 2 shows a word cloud within the political map of Colombia; it is essential to highlight that in both cases, respondents stated that the most effective training in EE and ESD took place during class time. In addition, EE and ESD training was also commonly offered through specialized training, congresses, conferences, and non-academic spaces.

TABLE 2 Numerical and statistical results for Likert scale questions.

Total responses per Likert option	Questions about EE						Questions about ESD					
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Option 4	328	332	156	163	116	269	327	261	124	172	128	247
Option 3	64	61	132	161	190	112	65	127	166	180	189	127
Option 2	8	6	90	68	83	17	10	16	86	43	72	27
Option 1	6	7	28	14	17	8	4	2	30	11	17	5
Mode	4	4	4	4	3	4	4	4	3	3	3	4
SD	0.56	0.56	0.94	0.83	0.81	0.67	0.54	0.59	0.9	0.75	0.81	0.68
Mean	4	4	3	3	3	4	4	4	3	3	3	4

TABLE 3 Response percentages by option.

Response percentage per Likert option	Questions about EE						Questions about ESD					
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
(%) 4	80.8	81.8	38.4	40.1	28.6	66.3	80.5	64.3	30.5	42.4	31.5	60.8
(%) 3	15.8	15	32.5	39.7	46.8	27.6	16	31.3	40.9	44.3	46.6	31.3
(%) 2	2	1.5	22.2	16.7	20.4	4.2	2.5	3.9	21.2	10.6	17.7	6.7
(%) 1	1.5	1.7	6.9	3.4	4.2	2	1	0.5	7.4	2.7	4.2	1.2

Table 4 shows the frequency of words used by the students. Notably, more training has been received in EE than ESD according to the total number of responses. It is important to note that the absence of training is more significant in ESD than in EE; this further supports the responses from the questions formulated on the Likert scale. On the other hand, the words "basic" can be linked to the subjects of basic sciences, which is one of the essential training components for engineers. Congresses represent a non-formal way of training in EE and ESD. In this sense, it can be inferred that universities create such events with a bias toward EE rather than ESD. These events are important as they show the progress of research in early and advanced stages, which encourages students to pursue lines of research, find new sources of information, establish new connections, and work collaboratively to generate new knowledge.

TABLE 4 Word count and frequency.

Word	EE		ESD	
	Frequency	%	Frequency	%
Subjects	104	23.3%	42	24.0%
Basic	35	7.8%	21	12.0%
Academic	59	13.2%	18	10.3%
Training	59	13.2%	18	10.3%
Courses	58	13.0%	18	10.3%
Conferences	39	8.7%	17	9.7%
Optional	17	3.8%	11	6.3%
Specialty	52	11.6%	9	5.1%
Congresses	19	4.3%	1	0.6%
None	5	1.1%	20	11.4%
Total	447	72%	175	28%

The data suggests a greater emphasis on EE over ESD based on the information provided by the students. The significant mention of "none" under ESD indicates a notable lack of training in this area. Universities seem to create events like congresses with a bias toward EE, which are crucial for showcasing research progress and encouraging students to engage in research activities and collaborations.

These findings align with the Likert scale responses, emphasizing the need for more balanced and comprehensive training in both EE and ESD to ensure holistic education in sustainable development for engineering students. The thematic analysis suggests that respondents consider several dimensions of EE crucial, highlighting the importance of involving people in practical and local experiences of environmental problems.

4 Discussion

The central precept of EE is to protect the planet from the human activity that is causing the depletion of natural resources. The EE seeks to solve this issue through environmental literacy, knowledge of the natural environment for the protection, restoration, or improvement of ecosystems (Carleton-Hug and Hug, 2010; Yanniris and Huang, 2018). Therefore, EE has evolved, especially in the present day, thanks to technological advances and instant communications. Now, the conservation and protection of natural resources are being taught to students in schools and universities through mobile applications or

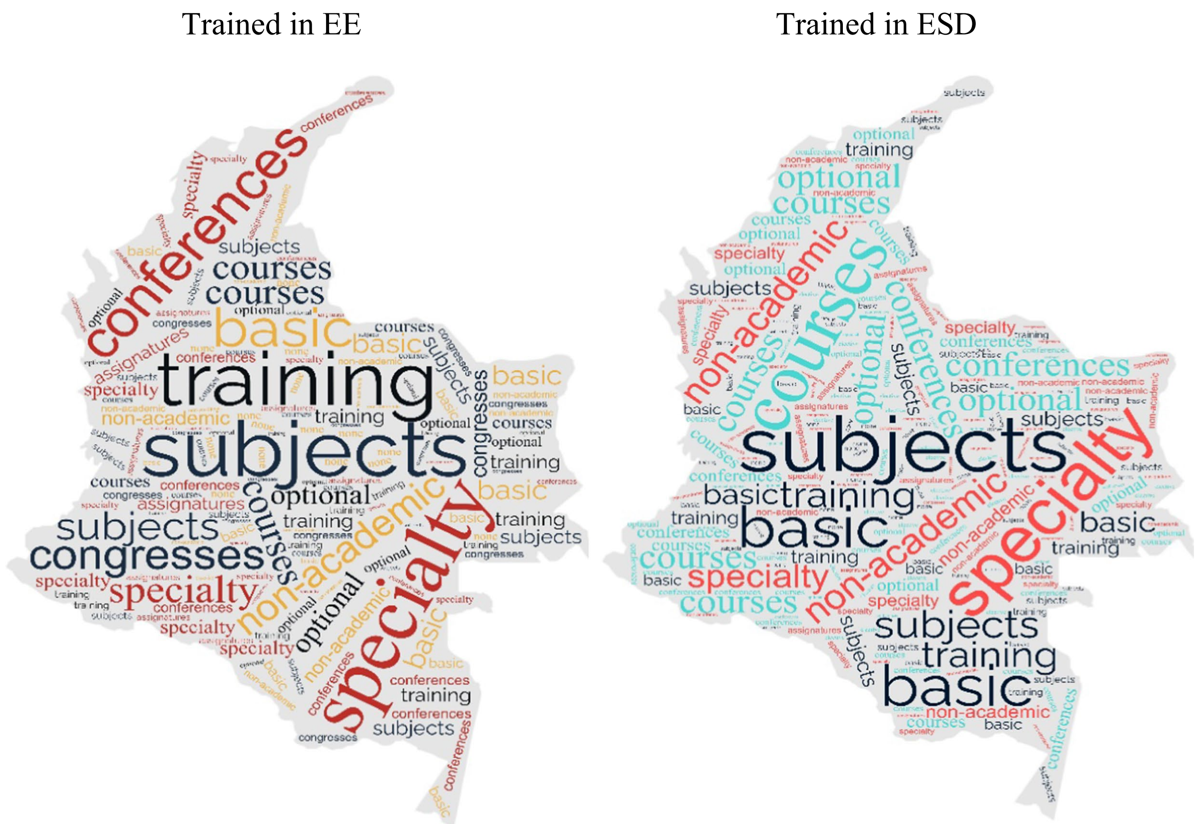

FIGURE 2
Word cloud of common activities where students were trained in EE or ESD. Trained in EE. Trained in ESD.

augmented reality processes, among many other methods (Andersson and Öhman, 2016; Pereira et al., 2020). This means that despite the background and research trajectory EE has, it can be adaptable and malleable to technological conditions. Based on the above, we can affirm that EE is contemporary and intergenerational, capable of evolving. However, it seems that modernity and adaptability have not changed this field's characteristics or purpose. Regardless of the technological tools or the pedagogical model used, EE continues to have a conservationist and protectionist purpose toward the environment (Schneider et al., 1993; De Andrade Santos and Toschi, 2015; Galvis-Riaño et al., 2020; Crispin et al., 2021).

ESD stands in opposition to EE and therefore against SD since ESD seeks to promote those principles of SD that are based on economic and social development principles while maintaining a balance with nature. According to SD theory, this balance must be achieved to secure natural resources for future generations. This precept is based on the affirmation that economic growth is necessary to maintain this complex balance, which is explicitly mentioned in SDG 8. However, said economic growth leads to a globalized trade that needs natural resources to sustain itself. Moreover, results have shown that economic growth has prevailed over social and environmental balance (Stern et al., 1996; Christmann and Taylor, 2001; Abbasi and Riaz, 2016; Ulucak et al., 2020). This inherent dilemma supports the statement that SD is an anthropocentric movement that is essentially against environmental protection movements such as EE.

In this sense, the students' responses can be interpreted as supporting the debates that arise within each educational approach. On one hand, the transformation undergone by EE after the last decade of the 20th century, especially in Latin America, where EE shifted from being apolitical and scientific to having a strong inclination toward protectionism. This shift facilitated its adoption by politicians and populist sectors who turned it into a political instrument (Elliott, 1995; Schild, 2016; Prusinski, 2024).

In this context, it cannot be ignored that Education for Sustainable Development ESD is not only a consequence of SD but also of the constant evolution of educational trends. In this case, it involves factors that distance themselves from protectionism, such as globalization and future thinking, among others (Hesselink et al., 2000). ESD, however, must reconcile the inherent problems and conflicts of SD, such as achieving social and economic balance without environmental sacrifice (McKeown and Hopkins, 2007). This debate includes contemporary issues such as energy transition and securing the economic support needed to achieve it.

In this regard, tensions arise particularly between economically powerful "developed" countries and those in the process of development, with economies that barely sustain the basics for their populations. What sacrifices must poorer countries make to achieve the balance between economy, society, and environment? How will they achieve the energy transition? Meanwhile, how willing are developed countries to finance or economically support the transition of poorer countries while also supporting their own transition?

ESD must be adaptable to respond to these concerns and tensions as the SD model is increasingly adopted in societies, particularly in economic sectors. ESD, in turn, should not standardize factors beyond the philosophical and epistemological ones to adapt to different cultures (Stevenson, 2006; Kitamura, 2014; Kopnina, 2014; González-Gaudiano, 2016; Aguilar, 2018). These cultures, in turn, should reinforce the transformation of ESD, giving it a less Westernized and more global vision.

Engineers have historically been on the side of developmentalism; they act as a natural modifier of the landscape and the environment. The solutions designed by these professionals are commonly an indicator of progress and development (Ulucak et al., 2020). Therefore, the responsibility of engineers toward the environment is of utmost importance. At first glance, the engineer should be trained in ESD and not in EE since it is difficult to conceive any infrastructure work that does not affect the environment. On the other hand, the results of our research show that engineering students in Colombia are more used to receiving EE-based training rather than one that is based on environmental protection. In turn, the responses of the questionnaire show that students understand SD, almost in the same proportion as EE; this is evidenced in the comparison between Q1 and Q7.

Thus, one could conclude that there is a mix of concepts and definitions within engineering education in Colombia. Therefore, there may be a gap in conceptual understanding, as students do not fully understand EE or ESD theoretical and practical knowledge. Furthermore, this incomplete or superfluous training is taught mainly in the curricular subjects. In conclusion, the problem lies in the curriculum. Moreover, there is a lack of training among professors, which supports our findings in previous research (Acosta Castellanos et al., 2020b).

Based on the results, there is a blending of EE and ESD; that is, they intersect and overlap on many issues. Theoretically, their characteristics and aims differ, but in practice, EE and ESD theories show broad similarities. In Colombia, government policies have led to EE being a more prominent, advocated, applied, and researched field than its counterpart, ESD (Mejía-Cáceres et al., 2020). Even so, society is accustomed to the terms and concepts of SD and understand the need for economic development as a driver of social and environmental factors (Londoño Pineda and Gabriel Cruz Cerón, 2019; Castillo et al., 2020; Pérez Vásquez, 2020; Liu et al., 2021; Pardo Martínez and Cotte Poveda, 2021; Tabares, 2021). Engineering students in this country are aware of this reality as the survey shows that even though they know more about EE, they also understand the concept and importance of SD. Therefore, education in Colombia, as in many countries, cannot be pigeonholed into a single movement; hence, the need for promoting new ways of understanding EE. To this end, we propose that EE continues to have the purpose of teaching university students about natural resources, their importance, and the environmental problems at a national and international level. Based on this literacy, students must understand their role as professionals in achieving sustainable development in harmony with the environment that favors human progress. In Colombia, especially within engineering education, Environmental Education for Sustainable Development (EESD) would be a more suitable model according to the characteristics of this country. The first record of EESD appears in Scopus in 1990 in an article called "Environmental Education for Sustainable Development?" by Disinger (1990). In this same database, there are only 15 results containing this denomination in their title. Essentially, these articles state that EE is a tool to achieve SD through courses, programs, and activities that educate the community about environmental problems. In the most recent articles on EESD, EE is seen as an essential component of the SD pillars: economy, society, and the environment (Shutaleva et al., 2020; Babalola et al., 2021).

Consequently, EESD would have the potential to mediate and fill the gaps that EE and ESD have in their application within engineering. EE has had significant achievements, but it has had little impact on stopping climate change or changing consumer attitudes in today's society, for example (Pérez Vásquez, 2020). This problem is further accentuated if one considers that EE has been implemented since 1970, despite the support it has globally received from the UN, national and sub-national governments, and non-governmental entities. Meanwhile, ESD seems to be following the same path as EE since, as evidenced by various authors, the integration of this movement within formal and non-formal education is still at its early stages. It is also notable that no country has yet achieved SD. Our intention is not to detract from the achievements of EE or ESD, but rather to seek mediation between the EE and ESD to overcome the limitations in the incorporation of sustainability in engineering curricula, especially in Colombia. Achieving this mediation would imply creating new arguments to evolve from a conservation EE to an EE based on environmental justice, where human beings are an important part of nature but not the main point of focus. To achieve this mediation, ESD must also renounce its anthropocentric purpose and put the environment at the forefront rather than the economic aspects. Incorporating these precepts into engineering curricula can lead to extensive discussions, but the authors note that Colombia has the right context and spaces in which to review these alternatives.

5 Conclusion

EE in Colombia has its own characteristics and nuances as it overlaps with SD in some aspects, as our results show. Therefore, EE in this country merges the anthropocentrism that predominates in SD and the environmental protection that characterizes EE. Even so, the predominant model of environmental education in engineering studies in Colombia continues to be EE since students are more familiar with this concept, while also being the most taught model in formal learning environments. On the other hand, ESD is less known and is less relevant in formal education curricula. However, students have shown great interest in learning more about this model.

Therefore, in the light of our research and other studies mentioned in this paper, it can be affirmed that engineering curricula in Colombia are insufficient in terms of the incorporation of topics such as SD and the SDGs into formal learning environments such as subjects, forums, and courses. On the other hand, according to the students surveyed, professors need to be more prepared to be able to integrate the topics of their specialty with the topics related to SD. To this end, it is essential to establish policies that strengthen training within universities so that ESD is widely implemented in HEI.

There are some studies that focus on Colombia, specifically on the possibilities of implementing ESD at different stages of education, both formal and non-formal (Flórez-Yepes and

Flórez-Yepes, 2015; Sepúlveda Chaverra, 2015; Gómez Agudelo, 2018; Rendón López et al., 2018a; Acosta Castellanos and Queiruga-Dios, 2022). As previously mentioned in this text, the environmental education policy was enacted by the government of this country in 2002 and has not undergone significant changes since then. Therefore, students entering various undergraduate programs come with a strong inclination and preference for protectionist discourses but are unaware of the role their future profession can play in a scenario increasingly permeated by Sustainable Development (SD). Thus, the different studies, including the one presented in this paper, can serve as a trigger for academia to promote a new educational policy focused on SD, supported and stimulated by ESD. By formalizing ESD at the governmental level, the ambiguities and uncertainties surrounding EE and ESD can be dispelled, with the hope that new generations of students will be truly literate in SD and that, in the case of engineering, they will be more effective in acting as a player beyond the technological aspect to achieve the desired SD.

Ultimately, results show that due to the unique and characteristic features of EE in Colombia, curricular experimentation with models such as EESD can be explored. Therefore, we urge researchers from Colombia and Latin America to use this instrument and validate the information provided in engineering programs to improve the engineering curricula and the results of the present research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

PA-C: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. AQ-D: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. JC-M: Conceptualization, Investigation, Resources, Writing – original draft.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Abbasi, F., and Riaz, K. (2016). CO2 emissions and financial development in an emerging economy: an augmented VAR approach. *Energy Policy* 90, 102–114. doi: 10.1016/j.enpol.2015.12.017

Acosta Castellanos, P.M., Dios, A.Q., and Ortegon, A.C. (2020a), "The lack of environmental education in the training of environmental engineers in Colombia", In SEFI (Ed.), SEFI 47th Annual Conference: Varietas Delectat. Complexity Is the New Normality, Proceedings, European Society for Engineering Education (SEFI), pp. 70–82.

Acosta Castellanos, P. M., and Queiruga-Dios, A. (2022). From environmental education to education for sustainable development in higher education: a systematic review. *Int. J. Sustain. High. Educ.* 23, 622–644. doi: 10.1108/IJSHE-04-2021-0167

Acosta Castellanos, P. M., Queiruga-Dios, A., Encinas, A. H., and Acosta, L. C. (2020b). Environmental education in environmental engineering: analysis of the situation in Colombia and Latin America. *Sustain. For.* 12:7239. doi: 10.3390/su12187239

Acosta-Castellanos, P. M., and Queiruga-Dios, A. (2022). Education for sustainable development (ESD): an example of curricular inclusion in environmental engineering in Colombia. *Sustainability* 14:9866. doi: 10.3390/su14169866

Aguilar, O. M. (2018). Examining the literature to reveal the nature of community EE/ESD programs and research. *Environmental education research*, 24, 26–49. doi: 10.1080/13504622.2016.1244658

Andersson, E., and Öhman, J. (2016). Young people's conversations about environmental and sustainability issues in social media. *Environ. Educ. Res.* 23, 465–485. doi: 10.1080/13504622.2016.1149551

Ardoin, N. M., and Bowers, A. W. (2020). Early childhood environmental education: a systematic review of the research literature. *Educ. Res. Rev.* 31:100353. doi: 10.1016/j.edurev.2020.100353

Babalola, A., Olawuyi, D. S., Babalola, A., Olawuyi, D. S., Belluigi, D. Z., and Pace, P. (2021). Advancing Environmental education for sustainable development in higher education in Nigeria: current challenges and future directions. *Sustain. For.* 13:10808. doi: 10.3390/su131910808

Badillo Mendoza, M. E. (2012). Política de educación ambiental en Colombia, 2002-2010. *Revista de Investigación Agraria y Ambiental* 3:89. doi: 10.22490/21456453.948

Biasi, P., Ferrini, S., Borghesi, S., Rocchi, B., and Di Matteo, M. (2019). Enriching the Italian genuine saving with water and soil depletion: national trends and regional differences. *Ecol. Indic.* 107:105573. doi: 10.1016/j.ecolind.2019.105573

Bowling, A., and Windsor, J. (2008). The effects of question order and response-choice on self-rated health status in the English Longitudinal Study of Ageing (ELSA). *Journal of Epidemiology and Community Health,* 62, 81–85. doi: 10.1136/jech.2006.058214

Builes-Vélez, A. E., Restrepo, J., and Martínez, J. D. D. (2024). The significance of sustainability in higher education: a view to the curricular proposal at a Colombian University. *Int. J. Sustain. High. Educ.* 25, 943–961. doi: 10.1108/IJSHE-09-2023-0423

Calderon-Madero, J. E., Suarez-Agudelo, E. A., Atencio-Sarmiento, F. A., Blanco-Donado, E. P., Oyaga-Martinez, R., and Tejera-Gonzalez, M. P. (2019). Applicability of the national policy of environmental education in educational institutions | Análisis de la aplicabilidad de la Política Nacional de Educación Ambiental en las instituciones educativas. *Espacios* 40:29.

Callejas Restrepo, M. M., Blanco-Portela, N., Ladino-Ospina, Y., Tuay Sigua, R. N., and Vargas, K. O. (2017). Professional development of university educators in ESD: a study from pedagogical styles. *Int. J. Sustain. High. Educ.* 18, 648–665. doi: 10.1108/IJSHE-02-2016-0031

Carleton-Hug, A., and Hug, J. W. (2010). Challenges and opportunities for evaluating environmental education programs. *Eval. Program Plann.* 33, 159–164. doi: 10.1016/j.evalprogplan.2009.07.005

Castillo, C., Da Silva, J., and Monsueto, S. (2020). Objectives of sustainable development and youth employment in Colombia. *Sustainability* 12:991.

Cavalcanti-Bandos, M. F., Quispe-Prieto, S., Paucar-Caceres, A., Burrowes-Cromwel, T., and Rojas-Jiménez, H. H. (2021). Provision of education for sustainability development and sustainability literacy in business programs in three higher education institutions in Brazil, Colombia and Peru. *Int. J. Sustain. High. Educ.* 22, 1055–1086. doi: 10.1108/IJSHE-07-2020-0247

Christmann, P., and Taylor, G. (2001). Globalization and the environment: determinants of firm self-regulation in China. *J. Int. Bus. Stud.* 32, 439–458. doi: 10.1057/palgrave.jibs.8490976

CODS (2020). Índice ODS 2019 para América Latina y el Caribe. Centro de los Objetivos de Desarrollo Sostenible para América Latina y el Caribe: Bogotá, Colombia. Bogotá: Índice ODS 2019 Para América Latina y El Caribe, 134.

Congreso de la República (2012). Ley 1549. Congreso de la República de Colombia

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *J. Appl. Psychol.* 78, 98–104. doi: 10.1037/0021-9010.78.1.98

Crispin, F. V. S., Arroyo, J. B. M., and Saenz, W. G. (2021). Ethical foundations of environmental education under the global perspective of the age of knowledge | Fundamentos éticos de la Educación ambiental bajo la perspectiva globalizada de la era del conocimiento. *Revista de Filosofia (Venzuela)* 38, 340–355.

De Andrade Santos, J., and Toschi, M. S. (2015). Aspects of environmental education: from conservationist to critical. *Fronteiras* 4, 241–250. doi: 10.21664/2238-8869.2015V4I2.P241-250

Disinger, J. F. (1990). Environmental education for sustainable development? *J. Environ. Educ.* 21, 3–6. doi: 10.1080/00958964.1990.9941931

Dlouhá, J., and Pospíšilová, M. (2018). Education for sustainable development goals in public debate: the importance of participatory research in reflecting and supporting the consultation process in developing a vision for Czech education. *J. Clean. Prod.* 172, 4314–4327. doi: 10.1016/j.jclepro.2017.06.145

Ekpiken, W. E., and Ukpabio, G. U. (2015). Youth empowerment in higher education for sustainable development of developing communities in Cross River state, Nigeria. *Int. Educ. Stud.* 8, 113–119. doi: 10.5539/ies.v8n9p113

Elliott, J. (1995). The politics of environmental education: a case-study. *Curric. J.* 6, 377–393. doi: 10.1080/0958517950060307

Elmassah, S., Biltagy, M., and Gamal, D. (2021). Framing the role of higher education in sustainable development: a case study analysis. *Int. J. Sustain. High. Educ.* 23, 320–355. doi: 10.1108/IJSHE-05-2020-0164

Ernst, J., and Theimer, S. (2011). Evaluating the effects of environmental education programming on connectedness to nature. *Environ. Educ. Res.* 17, 577–598. doi: 10.1080/13504622.2011.565119

Filho, W. L., Manolas, E., and Pace, P. (2015). The future we want: key issues on sustainable development in higher education after Rio and the UN decade of education for sustainable development. *Int. J. Sustain. High. Educ.* 16, 112–129. doi: 10.1108/IJSHE-03-2014-0036

Flórez-Yepes, G. Y. (2015). La educación ambiental y el desarrollo sostenible en el contexto colombiano. *Revista Electrónica Educare* 19, 1–12. doi: 10.15359/ree.19-3.5

Galvis-Riaño, C. J., Perales-Palacios, F. J., and Ladino-Ospina, Y. (2020). Conceptions about environment and environmental education by teachers from rural schools in Bogotá-Colombia. *Ambiente Sociedade* 23:2020. doi: 10.1590/1809-4422asoc20180200r1vu2020l4ao

Gómez Agudelo, M. (2018). Educación para el desarrollo sostenible. Una mirada a los proyectos ambientales escolares PRAE. *Libre Empresa* 15, 179–194. doi: 10.18041/1657-2815/libreempresa.2018v15n2.5360

González-Gaudiano, E. J. (2016). ESD: power, politics, and policy: 'tragic optimism' from Latin America. *J. Environ. Educ.* 47, 118–127. doi: 10.1080/00958964.2015.1072704

Hernández-Diaz, P. M., Polanco, J. A., Escobar-Sierra, M., and Leal Filho, W. (2021). Holistic integration of sustainability at universities: evidences from Colombia. *J. Cleaner Prod.* 305:127145. doi: 10.1016/j.jclepro.2021.127145

Hesselink, F., Van Kempen, P.P., and Wals, A.E.J. (2000). ESDebate: international debate on education for sustainable development, gland, Cambridge: IUCN, 2000. Available at: http://books.google.com/books?hl=en&lr=&id=V_45nJUTtZ8C&pgis=1 (Accessed July 17, 2023).

Jaeger, S. R., and Rasmussen, M. A. (2021). Importance of data preparation when analysing written responses to open-ended questions: an empirical assessment and comparison with manual coding. *Food Qual. Preference* 93:104270. doi: 10.1016/j.foodqual.2021.104270

Kaplan, A. D., Sanders, T. L., and Hancock, P. A. (2021). Likert or Not? How Using Likert Rather Than Biposlar Ratings Reveal Individual Difference Scores Using the Godspeed Scales. *International Journal of Social Robotics* 3, 1–10. doi: 10.1007/S12369-020-00740-Y

Kitamura, Y. (2014). The possibility of holistic safety education in Japan: from the perspective of education for sustainable development (ESD). *IATSS Res* 38, 40–47. doi: 10.1016/j.iatssr.2014.05.004

Kopnina, H. (2014). Education for sustainable development (ESD): exploring anthropocentric–ecocentric values in children through vignettes. *Stud. Educ. Eval.* 41, 124–132. doi: 10.1016/j.stueduc.2013.12.004

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology,* 22, 140–55.

Liu, Y., Samsami, M., Meshreki, H., Pereira, F., and Schøtt, T. (2021). Sustainable development goals in strategy and practice: businesses in Colombia and Egypt. *Sustain. For.* 13:12453. doi: 10.3390/su132212453

Londoño Pineda, A., and Gabriel Cruz Cerón, J. (2019). Evaluation of sustainable development in the sub-regions of Antioquia (Colombia) using multi-criteria composite indices: a tool for prioritizing public investment at the subnational level. *Environ. Dev.* 32:100442. doi: 10.1016/j.envdev.2019.05.001

Marouli, C. (2021). Sustainability education for the future? Challenges and implications for education and pedagogy in the 21st century. *Sustain. For.* 13:2901. doi: 10.3390/su13052901

Marouli, C., and Duroy, Q. (2019). Reflections on the transformative power of environmental education in contemporary societies: experience from two college courses in Greece and the USA. *Sustain. For.* 11:6465. doi: 10.3390/su11226465

Mastrángelo, M. E., Pérez-Harguindeguy, N., Enrico, L., Bennett, E., Lavorel, S., Cumming, G. S., et al. (2019). Key knowledge gaps to achieve global sustainability goals. *Nat. Sustain.* 2, 1115–1121. doi: 10.1038/s41893-019-0412-1

McKeown, R., and Hopkins, C. (2003). EE p ESD: defusing the worry. *Environ. Educ. Res.* 9, 117–128. doi: 10.1080/13504620303469

McKeown, R., and Hopkins, C. (2007). Moving beyond the EE and ESD disciplinary debate in formal education, vol. *1*. New Delhi: Sage Publications India Pvt. Ltd, B-42, Panchsheel Enclave, 17–26.

Mejía-Cáceres, M. A., Huérfano, A., Reid, A., and Freire, L. M. (2020). Colombia's national policy of environmental education: a critical discourse analysis. *Environ. Educ. Res.* 27, 571–594. doi: 10.1080/13504622.2020.1800594

Molano Niño, A. C., and Herrera Romero, J. F. (2014). La formación ambiental en la educación superior:una revisión necesaria. *Luna Azul* 39, 186–206. doi: 10.17151/luaz.2014.39.12

Mora-Ortiz, J. R. (2015). Los proyectos ambientales escolares. Herramientas de gestión ambiental. *Bitacora Urbano Territorial* 25, 67–74. doi: 10.15446/bitacora.v2n25.39975

Murray, P., Goodhew, J., and Murray, S. (2014). The heart of ESD: personally engaging learners with sustainability. *Environ. Educ. Res.* 20, 718–734. doi: 10.1080/13504622.2013.836623

Nikulchev, E., Silaeva, A., Ilin, D., and Malykh, S. (2021). Intelligent processing of open-ended questions in mass web-surveys. *Proc. Comput. Sci.* 186, 706–712. doi: 10.1016/j.procs.2021.04.193

Nomura, K. (2009). A perspective on education for sustainable development: historical development of environmental education in Indonesia. *Int. J. Educ. Dev.* 29, 621–627. doi: 10.1016/j.ijedudev.2008.12.002

Oviedo, H. C., and Campo-Arias, A. (2005). Aproximación al uso del coeficiente alfa de Cronbach. *Revista Colombiana de PsiquiatrÃ* 34, 572–580.

Pardo Martínez, C. I., and Cotte Poveda, A. (2021). The importance of science, technology and innovation in the green growth and sustainable development goals of Colombia. *Environ. Clim. Technol. Sciendo* 25, 29–41. doi: 10.2478/rtuect-2021-0003

Penalosa Farfan, L. J., and Paucar-Caceres, A. (2018). Regional development in Latin America as a way to promote education for sustainable development: the case study of the University of Ibague in Colombia, World Sustainability Series. Cham: Springer, 735–761.

Pereira, R. C. S., Dinis, M. A. P., and Gouveia, L. B. (2020). The use of mobile devices in environmental education, World Sustainability Series. Cham: Springer, 643–649.

Pérez Vásquez, M. A. (2020). Environmental policy challenges in Colombia against the challenges of the organization for economic cooperation and development (Oecd) and the sustainable development goals (SDG). *Analisis Politico* 33, 101–120.

Pita-Morales, L. A. (2016). Línea de tiempo: educación ambiental en Colombia. *Praxis* 12:118. doi: 10.21676/23897856.1853

Prusinski, E. (2024). What is political about a tree? Grappling with partisan divides in environmental education. *Environ. Educ. Res.*, 1–17. doi: 10.1080/13504622.2024.2330988

Rendón López, L. M., Escobar Londoño, J. V., Arango Ruiz, Á. J., Molina Benítez, J. A., Villamil Parodi, T., Valencia Montaña, D. F., et al. (2018a). Educación para el desarrollo sostenible: acercamientos desde una perspectiva colombiana. *Producción Limpia* 13, 133–149. doi: 10.22507/pml.v13n2a7

Rendón López, L. M., Londoño, J. V. E., Ruiz, Á. D. J. A., Benítez, J. A. M., Parodi, T. V., and Montaña, D. F. V. (2018b). Education for sustainable development: approaches froma Colombian perspective. *Produccion y Limpia* 13, 133–149.

República de Colombia (1991). Constitución Política de Colombia. Colombia: Presidencia de la Republica, 21.

Schild, R. (2016). Environmental citizenship: what can political theory contribute to environmental education practice? *J. Environ. Educ.* 47, 19–34. doi: 10.1080/00958964.2015.1092417

Schneider, H., Vinke, J., and Weekes-Vagliani, W. (1993). Environmental education: an approach to sustainable development. Organisation for Economic Co-operation and Development.

Sepúlveda Chaverra, J. D. (2015). Estado de la investigación sobre educación para el desarrollo sostenible: un análisis cienciométrico de la producción científica en el periodo 2005-2014. *Luna Azul* 41, 309–322. doi: 10.17151/10.17151/luaz.2015.41.17

Shi, X., and Liu, C. (2011). Survey of environmental education (EE): case study of higher education institutions in Ningbo. *Energy Procedia* 5, 1820–1826. doi: 10.1016/j.egypro.2011.03.310

Shutaleva, A., Nikonova, Z., Savchenko, I., and Martyushev, N. (2020). Environmental Education for Sustainable Development in Russia. *Sustainability*, *12*, 7742. doi: 10.3390/SU12187742

Stern, D. I., Common, M. S., and Barbier, E. B. (1996). Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development. *World Dev* 24, 1151–1160. doi: 10.1016/0305-750X(96)00032-0

Stern, M. J., Powell, R. B., Frensley, B. T., Stern, M. J., Powell, R. B., and Environmental, B. T. F. (2021). "Environmental education, age, race, and socioeconomic class: an exploration of differential impacts of field trips on adolescent youth in the United States" in *Environmental education research* (Routledge), 1–19. doi: 10.1080/13504622.2021.1990865

Stevenson, R. B. (2006). Tensions and transitions in policy discourse: recontextualizing a decontextualized EE/ESD debate. *Environ. Educ. Res.* 12, 277–290. doi: 10.1080/13504620600799026

Suárez-Perales, I., Valero-Gil, J., Leyva-de la Hiz, D. I., Rivera-Torres, P., and Garcés-Ayerbe, C. (2021). Educating for the future: how higher education in environmental management affects pro-environmental behaviour. *J. Clean. Prod.* 321:128972. doi: 10.1016/j.jclepro.2021.128972

Tabares, S. (2021). Do hybrid organizations contribute to sustainable development goals? Evidence from B Corps in Colombia. *J. Clean. Prod.* 280:124615. doi: 10.1016/j.jclepro.2020.124615

Ulucak, R., Danish, , and Khan, S. U. D. (2020). Does information and communication technology affect CO2 mitigation under the pathway of sustainable development during the mode of globalization? *Sustain. Dev.* 28, 857–867. doi: 10.1002/SD.2041

UN Secretary-General (1987). Report of the world commission on environment and development: our common future, UN. [New York]. Available at: http://digitallibrary.un.org/record/139811 (Accessed September 10, 2023).

UNESCO-UNEP (1993). Intergovernmental Conference on Environmental Ducation, Tbilisi, USSR, Tbilisi. Available at: http://www.gdrc.org/uem/ee/EE-Tbilisi_1977.pdf (Accessed October 29, 2021).

Weijters, B., Millet, K., and Cabooter, E. (2020). Extremity in horizontal and vertical Likert scale format responses. Some evidence on how visual distance between response categories influences extreme responding. *Int. J. Res. Mark.* 38, 85–103. doi: 10.1016/j.ijresmar.2020.04.002

Yanniris, C., and Huang, Y. S. (2018). Bibliometric evidence point to loci of empirical knowledge production in environmental education. *Cogent Educ.* 5, 1–14. doi: 10.1080/2331186X.2018.1542961