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Promoting ecological citizenship at the university level

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This review article analyses the role of the university in the promotion of ecological civic responsibility as an educational response to the global challenges of sustainability due to the present-day environmental crisis. By means of a documentary review of the main international conferences, regulatory frameworks and scientific literature on environmental education and sustainable development, it examines the policies and practices to be implemented in the university area. The results show growth in the integration of sustainability in academic programs and in models for sustainable campuses. It proposes various innovative pedagogical methodologies such as blended learning, character education, service-learning, and some of the emerging digital media like podcasting which promote ethical, critical and participatory learning. And it concludes that higher education must accept an active cross-disciplinary and interdisciplinary commitment to sustainability, thereby producing citizens capable of leading social and environmental transformations from the perspective of the ethics of care, responsibility and democratic participation.

KEYWORDS

sustainability, ecological civic responsibility, university, citizenship education, environmental education

1 Introduction

Mankind is facing unprecedented challenges in the area of sustainability. The current profound environmental crisis began in the mid-18th century, with the Industrial Revolution and a concept of progress that reduced nature to mere raw materials and was exclusively interested in the economic profit obtained from the exploitation of the earth (Olsen and Galimidi, 2009). Today, the consequences affect the whole planet. Environmental pollution, the loss of biodiversity, deforestation, climate change, global warming, depletion of natural resources and the decline of the quality of human life are, among others, examples of the serious problems which the humanity faces (Novo, 1997; Butler, 2018).

This first Industrial Revolution (18th and 19th centuries), characterized by the mechanization of production, the development of the railways and textile factories, was followed by a second revolution (late 19th century to early 20th century) which brought the expansion and development of new industries such as steel, oil and electricity; and a third (from 1970 on) which, among other innovations, promoted renewable energies, industrial automation and the digital era (González-Hernández et al., 2021). Almost three centuries after the first Industrial Revolution we are now facing that which Klaus Schwab—founder and executive president of the World Economic Forum—referred to in 2015 as the Fourth Industrial Revolution (21st century), marked by the convergence of emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data and robotics. In his book *The Fourth Industrial Revolution*, Schwab states that we are undergoing a more profound and fastmoving transformation than in the earlier eras, characterized by the convergence of digital, physical and biological technologies, and by their exponential impact on all sectors: from industry to ethics, politics and human identity (Schwab, 2016).

In this context, a not-insignificant issue is that the emerging technologies, together with the social and economic transformations they bring about, will favor more efficient management of natural resources. Moreover, they permit the development of predictive models and autonomous systems which can optimize decision-making in real time. In particular, artificial intelligence is seen as a strategic ally in the struggle for sustainability, as it offers innovative solutions in areas such as energy management, precision agriculture, reduction of waste or the optimization of urban infrastructures (Vinuesa et al., 2020; Bachmann et al., 2022).

Awareness of the need to preserve the natural environment became a demand of isolated movements and ecological collectives in the 1970s. It is important to acknowledge that among these was a group of British teachers who were extremely about this issue and achieved institutional support. In just a few decades, this concern has spread and has, practically, become generalized. Environmental protection is, today, a common tradition in the proposals of the most representative political parties and social movements (Alberti, 2000). According to the philosopher Llano (2017), among the values that characterize and define post-modern society are ecological culture, diversity and multi-dimensionality. It may be said that this is one of the symbols of our times. Some even believe sustainability to play the most essential central unifying role at this moment in the history of humanity (Bybee, 1991).

As a storyline of the evolution of environmental education, the field strengthened at Tbilisi in 1977, which articulated an interdisciplinary, lifelong, and participatory vision (UNESCO-UNEP, 1977); three decades of policy learning culminated in the UN Decade of Education for Sustainable Development (2005–2014), which consolidated these principles across curricula and systems (UNESCO, 2014); the 2030 Agenda then mainstreamed sustainability through Target 4.7, calling for all learners to acquire the knowledge, skills, and values for sustainable development (United Nations, 2015); and today the ESD for 2030 Roadmap emphasizes whole-institution approaches, action-oriented learning, and enabling policy environments (UNESCO, 2020). This trajectory now calls for cross-disciplinary, innovation-ready environmental education attuned to a digitized and interconnected world.

Beyond scientific-technological knowledge and a responsible political commitment to sustainable development, citizenship education is a fundamental tool to understand the complexity of the modern world and to promote critical and transformative social participation. But environmental education cannot stagnate in a world that is changing ever faster. In the present context, characterized by global interconnection, digitalization, urbanization and the climate crisis, we need cross-disciplinary, innovative environmental education. In addition, as we have already pointed out, the technological tools arising from the Fourth Industrial Revolution will enrich the educational processes by facilitating more immersive, personalized experiences based on real data from the surroundings (Crittano, 2024). There is no doubt that the sustainable processes are in flux and the proposals for education must reflect this. As a result, education for sustainability adopts different forms, resources and proposals (UNESCO Etxea, 2009).

Although intervention in education cannot resolve complex environmental problems, with the proper cognitive strategies and effective approaches, it can contribute to creating the cultural conditions which will allow citizens to define and acknowledge the

problems and their consequences, to evaluate their role in mitigating them and to strengthen their desire to contribute to the solution (Vega and Álvarez, 2005). The innovative responses that citizens, individually or in a group, can give to these changes and challenges will depend, to a certain extent, on their knowledge and capacity to understand the problems they face and to put into practice solutions from the recognition of a common destiny and commitment to social justice. Undoubtedly, the new generations must develop capacities for action, ethical decision-making, collaboration and the solution to complex problems.

The purpose of this paper then is to outline, in the context of environmental education, the definition and meaning of it, to explain some initiatives, to detect the strengths and weaknesses of the measures taken from a political and pedagogical perspective. In undertaking this analysis, it is important to bear in mind that many of the international policies in this field—including those issued by the United Nations—too often remain in the realm of discourse and institutional declarations, with limited implementation and real-world impact. The persistence of global inequalities, the lack of enforceable mechanisms, and the disconnection between global agendas and local realities demand a more critical approach. For this reason, this article also seeks to reflect on the gap between normative frameworks and effective practices, and to highlight educational strategies that respond to actual needs rather than rhetorical ambitions.

2 Environmental education. A political and pedagogical perspective

In the last 50 years, internationally, various conferences and summits have been held to deal with the issue of the environment and environmental education from a political and pedagogical perspective. These conferences have been relevant as they have shaped an international frame of reference guiding both public policies and educational practice, by recognizing that care for the environment is inseparable from a critical, informed citizen body that is committed to social and ecological justice. Here are the most important details.

In 1972, the United Nations organized the first conference under the title United Nations Conference on the Human Environment. It called for understanding of our surroundings and for actions which would not impact it negatively (United Nations, 1973). Within this framework, the development of an educational program on environmental issues at a worldwide level was agreed; so, in 1975, UNESCO, in collaboration with the United Nations Environment Programme (UNEP), launched the International Environmental Education Programme (IEEP). This program aimed to design and promote educational content, didactic materials and focused learning methodologies, from an interdisciplinary perspective, for school education (González and Arias, 2009).

Five years later, the Intergovernmental Conference on Environmental Education was held in Tbilisi (1977). Here it was decided environmental education should, by its very nature, be directed toward society as a whole. Outstanding among its aims is that it must motivate both students and their families to become interested in environmental problems and to find solutions that are within their reach. In addition, specific formation for teachers and professors is indispensable. The main characteristic of this education is that it is permanent and ongoing and is aimed at all citizens.

Moreover, the areas of formal and non-formal education must be complementary and share resources (UNESCO, 1978).

In 1992, the Earth Summit was held in Rio de Janeiro. The aim of this summit was to establish a new balanced world alliance through the creation of new levels of cooperation between countries, the key sectors of societies and peoples, seeking to reach international agreements which would respect everyone's interests and protect the integrity of the environmental system and worldwide development. In order to fulfill the aims of this summit, Chapter 36 of the report deals with the promotion of education, skills and decision-making. Outstanding is the presentation of the 21 Programme, better known as Agenda 21, which calls upon all local communities to elaborate their own Agenda to promote the sustainable development of their community (United Nations, 1992).

In 1997, the Earth Charter was begun and included the ideas and principles from the reunions of different National Committees, organizations and groups. It was published on June 29, 2000, in the Netherlands. This charter is a declaration on the fundamental ethical principles for the construction of a just, sustainable and peaceful society in the 21st century. It aims to inspire a new sense of global interdependency and shared responsibility for the well-being of the whole human family, of the great life community and of future generations. The Earth Charter presents 16 general aims based on four pillars: Respect and Care for the Community of Life, Ecological Integrity, Social and Economic Justice, and Democracy, Nonviolence and Peace (Earth Charter Commission, 2000).

In 2002, the World Summit on Sustainable Development was held in Johannesburg. There, representatives of all the peoples of the world reiterated their commitment to sustainable development and to "building a humane, equitable and caring global society, cognizant of the need for human dignity for all" (United Nations, 2002, p. 1). Its report presents an effective institutional framework for sustainable development, based on Programme 21 as proposed at the previous summit. Said framework "should be responsive to the needs of all countries, taking into account the specific needs of developing countries including the means of implementation" (United Nations, 2002, p. 65).

In December of the same year (2002), the United Nations General Assembly declared a Decade of Education for Sustainable Development: the DESD, from 2005 to 2014, precisely because it sees education as a force for change (UNESCO, 2006). To do so, a plan for international application was elaborated which summarizes the objectives and goals which must be reached during these years, in addition to presenting the main education milestones for sustainable development, the strategies to be carried out and the contributions of all participants from the national, regional and international perspective (UNESCO, 2014).

In September 2015, many heads of state and governments, representatives of the United Nations and civil society entities meet in New York during the 70th General Assembly of the United Nations, and adopted the Objectives for Sustainable Development (OSD). The Agenda of the United Nations for 2030 has defined 17 goals as a framework of reference for the transformation of our world. It states that to achieve the target of ensuring, in order to guarantee inclusive and equitable quality education and to foster lifelong learning for all, Sustainable Development Goal 4 highlights the necessity of equipping all learners with the competencies required to actively contribute to sustainable development. This includes education oriented toward

sustainability and responsible lifestyles, as well as the promotion of human rights, gender equality, and a culture grounded in peace and non-violence. Additionally, this objective underscores the value of cultural diversity and recognizes the essential role of culture in advancing sustainable development (United Nations, 2015, target 4.7).

These and other contributions of the international organizations are crucial in order to enact legislation and establish educational guidance which will foster social improvement in this area. We have seen how the international conferences established criteria and directives for environmental education. Among these it was decided that it must be interdisciplinary, permanent, be directed to all members of society, be open to both formal and non-formal education, include both students and families, and that specific training is necessary for teachers. During the United Nations Decade of Education for Sustainable Development, it was proposed that education develop critical thinking, empower to find solution to problems, be directed toward action, promote commitment, adopt an interdisciplinary and holistic focus, use multiple didactics resources, be significant and integrating, and consider both the local and global levels (UNESCO Etxea, 2009). It is a fact that its proposals have been achieved at all levels, even at a local level; and that the educational systems of the various countries, to a greater or lesser extent, have echoed these recommendations and, currently, environmental issues are addressed in national syllabuses.

Given the perspective of time, we can state that each international conference has brought about progress in comparison with the previous one, and as a whole have consolidated significant contributions. Since the Stockholm Conference (1972), the Earth Summit in Rio de Janeiro (1992), the World Summit on Sustainable Development in Johannesburg (2002), up to the OSD in 2015, international conferences have played a key role in the evolution of environmental education for sustainable development. Its implementation has dropped from macro to micro levels, which has permitted even local education communities to develop contextualized projects, aiming to change attitudes, empower citizens and improve the sustainability of nearby surrounding areas. The systems of education in developed countries (and more and more also in developing countries) have incorporated these guidelines, not only in traditional academic subjects, but as interdisciplinary focuses in national educational study plans. Moreover, the consolidation of this education is linked to active public policies, legislative frameworks and international assessments which demand that countries prove their progress in learning connected with sustainability (Tilbury, 2011, Bascopé et al., 2019). We will now see how this consolidation may be achieved in the specific area of university education.

3 Education for sustainable development in universities

The university has an inescapable responsibility in the training of citizens who can respond to the environmental challenges of the 21st century. This is so because it is the institution in charge of preparing specialists, technicians, teachers and professionals who, in the immediate future, will occupy strategic posts in society. In university study plans, environmental education must not be seen as a marginal content or as exclusive to natural sciences, but rather must have a multidisciplinary dimension that will permeate critical

thinking and the professional practice in all disciplines. From an interdisciplinary perspective, this education must be integrated organically into the diverse fields of knowledge. For example, in economics, models for sustainable development, ecological accountability and the impacts of consumption and production will be addressed. In law, environmental legislation and the acknowledgement of the rights of nature will be analyzed. Experimental and atmospheric sciences will provide empirical knowledge on climate change, biodiversity and natural cycles. In engineering, clean technologies, renewable energies and technical solutions that mitigate impacts will be developed. Ethics and anthropology will make for understanding of the values that guide our relationship with our surroundings and the cultural patterns which have led to the environmental crisis, by proposing frameworks for the transformation of mentalities and lifestyles (Jones et al., 2010). This integral vision responds to the demands of international organizations such as UNESCO, which foster an education for sustainable development based on integration, action and transformation (2020).

In the last few years, many universities have incorporated new undergraduate and postgraduate programs focusing on this topic, in accordance with the growing demand for professionals who can address the environmental, energy and social challenges of our times. The degree in Environmental Sciences has become one of the main training paths to tackle environmental transitions, the mitigation of climate change, the management of natural resources and the conservation of biodiversity. The technical universities have built up their offer with environmental engineering ecology degrees, in line with the need to train engineers who are committed to the sustainable management of the environment. Interdisciplinary programs such as the Science Degree in Data and Artificial Intelligence have also been created, which, although not focusing exclusively on sustainability, contribute to the development of technological solutions for this area.

Concurrently, at the postgraduate level there has also been a noteworthy increase. In Europe and Latin America, there has been consolidation of master's degrees focusing on sustainability from various perspectives: environmental, economic, business, territorial or technological. Some examples are the Master's Degree in Sustainability (University of Navarra, Spain), the Master's Degree in Growth and Sustainable Development (University of Castilla-La Mancha, Spain), the Master's Degree in Projects for Sustainable Development (EAN University, Colombia), the Master's Degree in the Economics of Resources and Sustainable Development (University of Bologna, Rimini), and the MSc in Sustainable Development (SOAS University of London). Highlighted are the offers of specific MSc's in the field of ecology at the Tecnológico de Monterrey (Mexico): Engineering and Environmental Technology, Environmental Management and Auditing, Marine Science and Technology, Environmental Systems, Administration of Energy and its Renewable Sources, Environmental Management Projects, Climate Change and Renewable Energies.

These programs and many others offer advanced courses in areas such as the circular economy, ecological regeneration, environmental governance and assessment of impacts. The abundance of these academic programs in the university area reflects the great efforts of the higher education institutions in playing an active role in the formation of citizens and professionals capable of leading the transformation to a sustainable future.

3.1 Promoting ecological public sense in universities

Education for sustainable development, as promoted by UNESCO (2020), explicitly includes this civic dimension by proposing a model for education that fosters social transformation through critical reflection, systematic thinking and responsible action. In this sense, universities are a privileged space for the consolidation of an ethics of care for the natural and social environment, through formative experiences that articulate sustainability with justice, fairness and participation. Incorporating education for sustainable development into the university is not a marginal option, but rather a contemporary demand which implies rethinking the study plans, methodologies and the social function of higher education. The integration of sustainability demands a systemic institutional transformation which will traverse all areas of knowledge and mobilize the students as agents for change (Giesenbauer and Tegeler, 2020).

Nowadays, respect for the environment and its protection are taken to be fundamental components of responsible citizenship, and so have direct implications for curricular development in the area of civic education (Lotz-Sisitka et al., 2013). In this vein, the International Association for the Evaluation of Educational Achievement (IEA) carries out regular research into topics regarding citizen education. The International Civic and Citizenship Education Study (ICCS), in its 2016 edition, analyzed young people's level of preparation to exercise active citizenship in the 21st century. The study assessed both their civic knowledge and their commitment to social issues, and incorporated, on this occasion, three new areas of special relevance for young people: environmental sustainability, social interaction in schools and the use of social networks as tools for civic participation (Schulz et al., 2016). This topical twist shows that ecological awareness has become an unavoidable focus both in research and in contemporary civic education programs.

There is no doubt that we are facing a great educational challenge because, although many young people show a growing ecological sensibility, a caring ethos and an active commitment to the defense of the environment, they do so from a lifestyle marked by high consumption and material well-being, which hinders the development of sustainable lifestyles (Francisco, 2015, n. 209). In light of this contradiction, educators must design pedagogical itineraries leading to an ecological ethic that promotes solidarity, social responsibility and care for the environment (n. 210). In this framework, ecological education cannot merely be understood as a process for the transmission of conceptual content related with the environment. Rather, it must be conceived as an integral formative experience promoting the development of the competences for sustainability by articulating knowledge, attitudes and values in contexts that are of significance for the students.

Civic education, then, can play a decisive role in the drive for an ecological citizenry. We considered that this contribution may be set out in complimentary plans: on the one hand, by promoting citizen participation within their specific capacities for the improvement of relations between the human race and their natural surroundings; and on the other, by promoting the critical awareness, democratic values and behaviors that enable active participation in the decision-making processes on environmental issues. This is, then, a pedagogical practice, firmly anchored in social reality, which promotes critical thinking, responsible decision-making and an active commitment with the society.

Its aim is not merely cognitive, but transformative: it seeks to have an impact on lifestyles, to bring about changes in individual and collective behaviors, and contribute in shaping a solidary society, a caring culture and joint responsibility for the environment (Francisco, 2020).

An education for sustainable development focusing on commitment must be grounded on a pedagogy based on values, which promote critical thinking, the capacity for systemic analysis and the creative search for solutions to socio-environmental challenges. This learning focus is marked by being directed toward action, encouraging the active participation of students in decision-making processes, and empowering them as responsible citizens. To reach these objectives, innovative learning experiences must be designed that focus on participation, inquiry and the collaborative resolution of real problems. It is, ultimately, a transformative learning which not only facilitates understanding of the causes and consequences of environmental problems, but also offers the pedagogical conditions for the students to be actively involved in their amendment by developing key skills for sustainability from an interdisciplinary and critical perspective (UNESCO Etxea, 2009).

Innovation in this or any other field demands the introduction of practices that imply an improvement in the quality of what is being done. Substantiated pedagogical practices are needed in the theoretical area, as a route to ethical action. Teachers should find new focuses for their subjects so that, apart from learning specific content, the students will develop civic-social values and assimilate skills-based learning (Naval and Arbués, 2017).

Before specifying which pedagogical actions or strategies may contribute, from a social and civic dimension, to the achievement of the stated objectives, we must make an aside to consider a relevant point. This is that, in the context of higher education, some universities have made a commitment with sustainability not only in the areas of learning or research, but also from in the management of their own spaces and resources. A relevant example is the University of Navarra, in Spain, which, in its Strategy 2025 includes transversal sustainability, with subjects, seminars, and teaching innovation projects linked to the OSD. The Pamplona campus, with almost 2,680 acres and 4,190 trees of 173 different species, has obtained the Green Flag Award in seven consecutive years, as an international acknowledgement of the quality of its green spaces. This university inspires a sustainable campus model as a coherent expression of its educational mission and its social responsibility. The initiative is part of a strategic plan which contemplates integral measures for energy efficiency, water management, sustainable mobility, biodiversity conservation, waste reduction and the fostering of responsible habits among the whole university community. The sustainable campus project of the University of Navarra not only seeks to minimize the environmental impact of its facilities, but also to create a coherent educational environment where the students will have significant experience of sustainability in their everyday lives. Through awareness activities, volunteer environmental programs, actions for the improvement of the natural surroundings of the campus and the interdisciplinary integration of sustainability into the study plans, it boosts experiential learning that strengthens care values, responsibility and participation.

Other outstanding examples may be found at the following universities:

- Western Sydney University (Australia). World leader in contribution to the OSD in the Times Higher Education Impact Rankings 2023.
- Environmental Campus Birkenfeld. Trier University of Applied Sciences (Germany). The only 'zero emission university' in Europe.
- Emory University (United States). Recognized as the top performer in the 2024 Sustainable Campus Index, a publication of the Association for the Advancement of Sustainability in Higher Education (AASHE).
- Pontificia Universidad Javeriana (Colombia). Its Sustainable Campus program includes national and international policies and acknowledgements, constant communication on advances and a focus on the OSD through specific actions on water, energy and waste reduction.
- Salisbury University (United States). In 2024, it launched the Gulls Go Green initiative, to draw attention to and coordinate the efforts of the whole community in social, economic and environmental projects on campus.

These examples show the variety of approaches, from heritage restoration projects and the use of renewable energies to the financing of student projects and care for biodiversity which universities are adopting to convert their campuses into learning ecosystems and showing the real practice of sustainability. In this way, the campuses become living spaces for learning and a true laboratory for the development of ecological and citizen skills. While student interest in sustainability is growing, research shows a persistent attitude-behavior gap in pro-environmental action. Psychological barriers—limited cognition, social comparison, sunk costs, and perceived risks—can impede consistent behavior change (Gifford, 2011). Pedagogies should therefore pair motivation with behavioral scaffolds and opportunities for practice.

3.2 Pedagogical practices to inspire ecological civic responsibility

In order to make this approach effective in the university area, apart from the projects for sustainable campuses, it is fundamental to incorporate pedagogical teaching strategies that not only transmit knowledge but also favor the personal and collective involvement of the student body in the improvement of the environment. In particular, pedagogical practices such as blended learning, character education, service-learning, or the use of emerging cybermedia and communicative formats that enable the development of environmental narratives grounded in lived socio-ecological engagement arise as potent tools to articulate academic content grounded in authentic experiences of environmental responsibility.

3.3 Blended learning

Environmental education is the key to understanding the relationships between the natural and social systems, and to achieve a clearer perception of the importance of the sociocultural factors at the origin of environmental problems. For this reason, we consider that blended learning is particularly relevant for environmental education as it responds to the complex, interrelated and systemic nature of present-day ecological challenges. Compared to the fragmentation of knowledge which characterizes many

traditional educational proposals, blended learning offers a holistic perspective which conveys knowledge of different disciplines with real and contextual experiences. This integration favors deeper understanding of environmental problems while allowing for the active participation of students in the search for solutions (Arbués, 2018).

Research on integrated and blended designs in sustainability higher education shows consistent benefits for student engagement and competency development, though evidence comes mainly from multi-site case analyses and course-level studies. Brundiers et al. (2010) synthesize capstone and project-based courses with real stakeholders, reporting deeper problem understanding and transferable skills (systems analysis, collaboration). Ongon et al. (2021) use surveys and reflective data in interdisciplinary modules and find gains in critical thinking and decision-making, albeit without counterfactuals. Lozano et al. (2017) map program-level alignment with sustainability competencies, showing strong curricular coherence but no estimates of effects on student performance. Overall, integrated/blended approaches appear to involve students in analyzing and intervening in their surroundings and to build key sustainability skills (critical thinking, teamwork, complex problem-solving, responsible decision-making), while highlighting the need for more comparative and pre-post designs.

Undoubtedly, integrated interdisciplinary learning of varied knowledge and disciplines (humanistic, philosophical, scientific, artistic, etc.), will allow the students to perceive environmental problems in their true dimension, and bring us closer to the predicament of the society in which we live by connecting humanist proposals with the challenges of innovation.

3.4 Character education

In the context of contemporary socio-environmental challenges, various studies coincide in stating that sustainable development cannot merely be taken as a technical or scientific issue, but must also imply training in values and moral and civic virtues and attitudes. The strengthening of moral character and the sense of shared responsibility are essential factors in education aiming for the common good and care of the planet.

The literature is predominantly conceptual and mixed-methods. Collado and Staats (2024) argue, from a conceptual analysis and synthesis of youth studies, that sustainability entails a moral dimension requiring deliberate virtue formation (e.g., responsibility, care), which must be addressed by character education. Naval et al. (2019) combine theoretical grounding with empirical illustrations in civic education contexts, linking belonging, shared responsibility, and agency to pro-social, pro-environmental dispositions; however, measures are mostly attitudinal and non-experimental. In fact, strengthening young people in their sense of belonging to a global community, to shared citizenship, prepared to assume collective responsibilities to address the complexity and controversy of a common destiny, should be a relevant objective for education (Naval et al., 2019). In this sense, it seems necessary that students develop the cognitive skills and the ethical and social values, which allow the formation of fairer societies. Current evidence supports character education as a necessary complement to technical knowledge, while future work should assess behavioral outcomes with robust designs.

3.5 Practice through service learning

Education for sustainability prepares to develop behaviors and practices which will allow people to not only understand but also to be involved in finding the solutions they need. In this sense, service-learning is a powerful educational practice which combines the mission of service and assistance to the community with that of learning. It is set to become a potent movement for social transformation, mainly because it can go beyond the schoolrooms and transform education into practical action (Naval et al., 2019).

Instead of being limited to the learning of abstract knowledge, service-learning allows the students to be actively involved in the resolution of real environmental problems, which favors a deeper and more significant comprehension of contents while simultaneously developing key skills for sustainability. Among these are systemic thinking, empathy, civic responsibility, ethical decision-making and teamwork (Martín-Sánchez et al., 2022).

Regarding research in this field, various studies have shown that this methodology promotes transformative learning, as it places the student at the center of the educational action, promoting commitment to the community and the natural surroundings (Aramburuzabala and Cerrillo, 2023). In addition, service learning contributes to the ownership of the values and attitudes needed to confront global challenges in a critical and supportive way, by articulating the cognitive, ethical and emotional dimensional of learning (Ribeiro et al., 2023). More specifically, a meta-analysis of 62 studies with more than 11,800 students found moderate, significant effects on civic engagement, social skills, attitudes, and academic achievement, stronger when programs included curricular integration, student voice, community partnership, and structured reflection (Celio et al., 2011). Complementing this, Ribeiro et al. (2023) reported a university service learning case in Portugal (15 student facilitators training at least 220 peers on Sustainable Development Goals) and, via qualitative coding of reflection journals (NVivo), documented SDG literacy gains, personal/professional growth, and perceived awareness increases among recipients; limits include small, non-probabilistic samples and no control group. The cumulative evidence supports service learning as an effective route to sustainability competencies when designed to best practice and institutionally supported.

3.6 Emerging cybermedia such as podcasting

In the university context, exploring new media formats—such as vlogs, podcasts, and other digital platforms—can foster environmental education that is more meaningful, critical, and socially committed. Podcasting is especially salient because it combines accessibility with asynchronous, low-threshold production and an emphasis on active listening. These affordances help students develop a personal connection with course content and sustain engagement with contemporary ecological challenges, while allowing instructors to scaffold inquiry, discussion, and reflection across time and space.

Podcasting also amplifies voices historically underrepresented in environmental discourse. The Breaking Green Ceilings example illustrates how first-person, intersectional narratives can build

community, surface lived experience, and develop critical ecological literacy. By centering environmentalists from racialized, Indigenous, and disabled communities, the podcast links ecological problems to questions of justice and participation, modeling an inclusive and engaged form of environmental citizenship (Mulki and Ormsby, 2021).

Beyond dissemination, course implementations and reviews indicate that podcast tasks support skill development and motivation. When students script, record, and edit episodes, they practice inquiry, evidence curation, and audience-aware communication; collaborative workflows distribute roles (host, researcher, editor) that cultivate teamwork and project management. Studies report gains in communication skills, teamwork, and reflective learning, and consistently associate podcast assignments with active listening and sustained engagement—benefits that align with ESD competencies and with authentic, student-centered assessment (Celaya et al., 2020; Van den Berg et al., 2022).

Curricular integrations in conservation and environmental science show the feasibility and reach of podcasting within and beyond the classroom. The Deer University case demonstrates how a course-embedded podcast can connect academic content with practitioner knowledge and public audiences, disseminating science-based information to stakeholders outside higher education. Such designs leverage the medium's low cost and scalability to maintain engagement, strengthen eco-literacy, and counter misinformation in digital ecosystems, while offering students authentic public-facing tasks (Strickland et al., 2021).

These cybermedia also enable virtual learning communities organized around shared interests. In such spaces, learners co-create knowledge through participatory and horizontal dynamics—commenting, remixing, and iterating on each other's work. This participatory ethos rests on collaboration, open knowledge, and collective value production, offering a cultural substrate that supports the co-construction of situated ecological understanding and civic agency (Vera, 2014).

Looking ahead, AI-driven personalization may help tailor audio content to diverse learner needs—adjusting difficulty, pace, and examples to prior knowledge and interests. This promise is early-stage and requires careful evaluation for equity, transparency, and privacy, but it points to complementary tools that could widen access and support inclusive environmental education when thoughtfully integrated (Do et al., 2024).

Methodological note on the evidence. Current findings derive mainly from case studies, mixed-methods evaluations, and reviews. Reported benefits cluster around engagement, reflective learning, communication, and teamwork; however, many studies are descriptive or perception-based, and effect sizes are rarely estimated. Stronger designs—pre-post measures with comparison groups, rubric-based performance assessments, analysis of authentic artifacts (episodes, scripts, peer feedback), and follow-ups on transfer to civic action—are needed to establish impact and transferability across institutional contexts and student populations.

4 Conclusion

In this work we have analyzed how the universities can incorporate sustainability into their training, research and

management functions, by presenting significant experiences of sustainable campuses and innovative academic programs. Our study is a narrative document review, not a systematic review; therefore, it entails some limitations inherent to said methodology. Source selection relied on author judgment rather than a preregistered protocol, which introduces potential selection bias. Coverage is non-exhaustive and constrained by language, availability, and an emphasis on well-documented international frameworks, so some perspectives may be underrepresented. We did not conduct formal critical appraisal or quantitative synthesis, which limits reproducibility and precludes effect-size estimation. Findings are interpretive, not causal, and should be read as a conceptual synthesis that proposes directions for curriculum design, pedagogy, and institutional policy, rather than empirically testing those directions.

The problem of the environment is neither exceptional nor transient. It is a global crisis that affects our civilization, which means the problem must be addressed in a profound, interdisciplinary, non-simplistic manner. In this context, higher education must play an active role in the formation of citizens who are committed to sustainability. Although environmental education is an ongoing learning process which goes beyond the temporal limits of formal schooling, the university stage is a crucial tipping point in the cultural, ethical and professional formation of the individual. At this educational level, the students do not only consolidate the technical or scientific knowledge corresponding to their subject, but are also shaped as citizens capable of critical intervention in society. For this reason, civic education at a university level—taken as the growth of attitudes, values and skills for democratic participation and commitment to the common good—plays a fundamental role in the formation of an ecologically aware citizenry. The concept of ecological public spirit is ever more relevant, as it integrates the environmental dimension with citizen education and promotes an ethics of care, intergenerational responsibility and active participation in social life.

Environmental education, as pointed out at international conferences, must be interdisciplinary and holistic and promote the acquisition of values and the development of critical thinking. Its focus must be the solving of local and global problems, together with decision-making, so that it can be applied to real life. In this way, environmental education leads the student to participate in their own learning, through the use of different resources and methodologies. Specifically in this work we have shown how blended learning, character education, service-learning, and the application of emerging cybermedia and communicative formats—such as podcasting—are among the practices which may contribute to fostering ecological civism among students. These tools, by enabling participatory, narrative-driven and inclusive approaches, offer powerful resources for shaping environmentally conscious and socially engaged university learners.

The OSD 4 (quality education) seeks to increase the number of young people and adults with the necessary technical and professional skills for decent employment and entrepreneurship. It also pursues the formation of the vulnerable, by guaranteeing that all students gain the knowledge and skills needed to foster sustainable development. However, there are various challenges to its implementation, particularly in regions such as Latin America and sub-Saharan Africa.

Among others, these include: (1) ongoing significant gaps between urban and rural areas; (2) the fact that many institutions lack the appropriate installations, didactic resources and technology, which limits the quality of learning; (3) the shortage of skilled teachers and unstable labor conditions affect the quality of teaching; and (4) investment in education continues to be limited -and scarce- in many countries, which impedes the effective implementation of inclusive and quality educational policies.

In spite of this and of the generally pessimistic tenor of discourse regarding the future, those of us who address this task with hope and optimism -and somewhat utopian perhaps- believe that study plans must include what is worthwhile teaching. Environmental education is not simply one more subject, but rather is the basis for students to understand the profound links between society, economics and nature. We must not forget that we live in a community, that social links are indispensable, that the global problems invite us to participate in their solution and that we must consider the future generations. Education has a vital role to play in this process.

Industry 4.0 and sustainability are not opposing forces; they may be allies. We can construct a future where technology and responsibility go hand-in-hand. On this point, industry has a major responsibility in leading the change to a more sustainable and ethical industrial model. In the Fourth Industrial Revolution, the adoption of technology does not merely offer companies an increase in productivity, but also the opportunity to reduce their environmental footprint through the optimization of processes, the efficient use of resources and the minimization of waste. This dimension should be included in university study plans and in the agenda of the organizations, as it prepares future professionals to design and direct industrial solutions with a low environmental impact. The combination of technological innovation, education and collaboration is the key to achieving this shared objective of saving the world and guaranteeing the well-being of future generations.

Lastly, we offer these recommendations aimed primarily at universities and policymakers to align Education for Sustainable Development (ESD) with the 2030 Agenda through whole-institution approaches, action-oriented pedagogy, and enabling policy frameworks: at the institutional level, adopt a university-wide sustainability and ESD policy with targets, budget, and public reporting; establish an ESD office and a multi-stakeholder council; embed sustainability learning outcomes across all degrees; expand project-based and service-learning courses and interdisciplinary capstones; use authentic assessment and micro-credentials; invest in faculty development with time and incentives; activate student leadership and use the campus as a living laboratory; ensure equity and digital inclusion; and monitor progress with clear indicators and an annual report. At the system level, integrate ESD outcomes into accreditation and program review; set lecturer standards in ESD pedagogy and assessment; create competitive and performance-linked funding for curriculum redesign and living labs; upgrade infrastructure and connectivity; publish national ESD indicators through open data portals; support consortia and community-industry partnerships; and require change-management plans that prevent tokenism and ensure co-design with students and social actors.

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

EA: Conceptualization, Supervision, Investigation, Writing – original draft. IC: Conceptualization, Investigation, Supervision, Methodology, Writing – review & editing. CN: Conceptualization, Project administration, Supervision, Writing – review & editing, Investigation.

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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.

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