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Pathways to Sustainability Require Collaboration and Innovation Arguments for the Inclusion of Communication Competences in Environmental Sciences and Related Higher Education

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Abstract:

Introduction: Steps towards sustainability require an evaluation of the interconnections among environmental, social, and economic factors. To address global societal and environmental challenges, distinct actors employ concepts and frameworks, speak a common language, and prioritize diverse issues and goals. This situation triggers 'communication gaps' that frequently result in misunderstandings and impasses. However, it is through effective communication that these gaps can be bridged, empowering each actor to play an integral role in fostering a collaborative framework that supports problem-solving and actions towards sustainability. This work examines the significance of communication in facilitating transdisciplinary collaboration, a crucial aspect of pursuing sustainability amidst the complexities of current global challenges.

Methods: A literature review was conducted using targeted keywords related to communication, collaboration, and sustainability education. Additionally, a qualitative survey of over 130 master's curricula and academic training offerings from universities in Europe and the United States was performed, utilising the KeyStone Master Studies database and supplementary Google searches for training programs.

Results: These findings indicated a limited and inconsistent inclusion of communication training, particularly beyond technical writing or presentation skills. Existing approaches fall short in preparing students to navigate interdisciplinary dialogue, address cognitive divergences, and facilitate co-creative problem-solving - all vital to advancing sustainability initiatives.

Conclusion: Higher education programs in environmental sciences and engineering must adopt a more comprehensive approach to communication. By embedding communication theory, interpersonal dynamics, and strategic engagement into curricula, institutions can better equip future professionals to lead and collaborate effectively in sustainability-oriented contexts.

Keywords: Communication, sustainability, academic education, collaboration, environment.

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1. INTRODUCTION

Current worldwide environmental challenges encompass coping with the effects of severe climate occurrences and biodiversity decline, which concurrently endangers ecosystem sustainability, impacting the economy (*e.g.*, WEF, 2024) and all social dimensions. There is an increasing trend to recognize that every aspect

of nature, economy, and society is interconnected (IUCN, 2024). Sustainable pathways should enable nature, society, and the economy to thrive in harmony, maintaining a balance that ensures an optimistic future and prosperity. Working towards sustainability requires open communication channels between distinct actors, with divergent visions and interests, from the three poles - economic, social, and environmental (Gey *et al.*, 2023). The World Economic Forum emphasizes that the global economy relies heavily on natural resources (WEF, 2024). For decades, the "Brundtland report - Our Common Future" (Brundtland, 1987) set the scene for sustainability by declaring that "*At a minimum, sustainable development must not endanger the natural systems that support life on Earth*".

Professionals working in natural resources and environmental management can testify to the importance of engaging, communicating, and collaborating with all types of stakeholders and audiences. Collaborative work among diverse stakeholders (*e.g.*, researchers, public and private organizations, decision-makers, and civil society) is both most relevant and challenging (Illingworth, 2020; Kalinauskaite *et al.*, 2021). Kling *et al*. (2019) suggest that managing conflicts over natural resources depends on effective communication designed to build trust among stakeholders, a notion corroborated by Lie *et al*., who suggest that collaboration barriers remain in place when there is no effective and transparent communication (Li *et al*., 2022).

Following the decades of interaction with a variety of stakeholders, researchers, decision-makers, the media, and the civil society, it was observed that communication discomforts, misunderstandings, distortions, and biases can hinder, the success of projects, initiatives and collaborations, particularly in multidisciplinary and multicultural contexts that are crucial to ensure sustainability (Barbosa, 2025).

Professionals working in the fields of engineering, environmental sciences and sustainability, due to the nature of their work, have to interact not only with specialists from multiple scientific and technical fields - including engineering, natural sciences, and various areas of economic, social and human sciences - but also with numerous social actors, such as academics, politicians and other decision-makers, governmental and non-governmental organizations, and the media and the civil society as a whole. Situations where these challenges arise are coordination of multidisciplinary teams, project development, living labs and communities of practice, public consultations - for example as part of Environmental Impact Assessment processes - negotiations, and international and multicultural collaborative dynamics (Besley and Dudo, 2022; Braslauskas, 2012; Chen, 2010; Doodly et al, 2000; Klenk &, 2017; Klenk, 2018; Yuges, 2020; Velez *et al*., 2022; Zhuang *et al*., 2021).

In the business sector, it is widely acknowledged that a corporation's success is directly dependent on co-creative communication, empathy, and dialogue. Azevedo (2021) refers to pertinent dimensions of communication, such as the horizontality of relationships and co-responsibility in problem-solving. The author also highlights the importance of investigating and clarifying the intrinsic motivations behind initiatives that have not yet been articulated, as well as promoting non-confrontational active listening. Notably, creativity training is especially valued in organizational environments for enhancing employee creativity (Roystone and Reiter-Palmon, 2017).

Passow and Passow (2017) elaborated on the competencies that undergraduate engineering programs should enhance, saying that the success of engineering practice relies on both technical and social aspects, emphasizing the importance of integrating non-technical skills within technical education. In line with this perspective, other authors agree that engineering education should help students acquire abilities like communication, teamwork, problem-solving skills, and encourage creative thinking and stepping out of the "comfort zone" (Armstrong, 2009; Pereira Pessoa, 2023).

Communication is also considered an employment asset, influencing job performance and career development (McCollun *et al*., 2020). It is widely agreed that effective communication is fundamental to the success of a business and to navigating complex professional environments (Doodley *et al*., 2000; Wangari *et al*., 2019; Azevedo, 2021; Kwame and Petrucka, 2021; Yuges, 2020). However, research institutions and other organizations often overlook communication challenges and are not sufficiently attentive to the relevance of this tool (Weingart and Joubert, 2019). Several contributions suggest that professionals from all areas should receive communication training (Barbosa, 2025; Holmesa *et al*., 2018; Illingworth, 2020; O'Connor *et al*., 2023; Salam *et al*., 2022; Wetkamp *et al*., 2023).

Furthermore, links between communication, collaboration, creativity, and the ability to positively interact with various audiences are recognised (Beghetto and Madison, 2022; Braslauskas, 2021; Burrowsa *et al*., 2022).

This work examines the significance of communication, encompassing technical, interpersonal, and strategic dimensions, in fostering transdisciplinary collaboration that is essential for addressing sustainability challenges. The specific objectives of this study are twofold: i) to contribute to the understanding of communication, expanding awareness of interconnectedness among communication, collaboration, creativity, and problem solving, and ii) to gather data to assess the presence of communication training in higher education related to environment and sustainability-related topics.

2. MATERIALS AND METHODS

2.1. Literature Overview

To contribute to both objectives, a literature search was conducted to provide a broad overview and insights into current developments. The frame of this work did not include the purpose of an extensive literature review. The

keywords used—"communication," "collaboration," "training," "teaching," and "sustainability"—were selected based on their recurrence in the literature and thematic relevance to transdisciplinary education. After identifying relevant papers, some literature cited by these selected publications was also consulted and analyzed. The results are presented in sections 3.1 and 3.2.

2.2. Search for Communication Presence in Higher Education Curricula

The evaluation of subjects related to communication in the curricula of master's programmes in the field of environmental sciences needs to have boundaries, to ensure feasibility and consistency. The international context chosen for the survey was Europe and the USA, as these countries have been following environmental protection practices for several decades (*e.g.*, Brundtland, 1987; Dunlap *et al.*, 2001). The KeyStone database was chosen for its structured, academic program listings across Europe and the USA. The search was conducted in April and May 2022.

Google was used to capture other training not catalogued in formal databases, to complement the results, using verification through official university web domains. Results for the geographic contexts of Europe and the USA are presented in Section 3.3.

3. RESULTS

3.1. Insights on Communication and Perception Processes

Communication is a dynamic process that evolves with language and the means of delivering a message. Table **1** provides examples of widely known languages and communication processes or media. It is essential to acknowledge that the challenges and opportunities in communication are not static; they evolve over time. This necessitates society's ability to be flexible and adapt to new contexts and means of communication, particularly in the realm of technology-mediated communication (*e.g.*, Berry, 2006; Hassel, 2017; Fauville *et al.*, 2021).

Table 1. Communication languages, methods, and media.

Communication Languages	Examples of Communication Methods and Media
Aural	Radio, audio, telephone, and internet-based
Kinetic	Experiential learning, peer-to-peer communication
Written	Books, leaflets, articles, email, and social networks
Visual	Films, pictures, photographs, objects
Emotional	Arts (such as music and theatre), trusted people.
Oral (face-to-face)	Focus and discussion groups; presentations

Adapted from Young (2014) and Barbosa and Matos (2017).

McCollun *et al*. (2020) analyzed technical communication in the scope of environmental engineering curricula (in the USA), more exactly at the United States Military Academy (West Point). Although acknowledging that communication is a highly relevant skill and that engineers strongly need it, this work focused on oral and written technical communication, understanding it as "effective listening, reading, speaking, and writing" (McCollun *et al*., 2020). The authors identified numerous opportunities for written and oral communication within the West Point academic program, and their analysis of individual and group technical communication events aimed at enhancing the curricula, demonstrating the effectiveness of the West Point curriculum in this regard.

Communication processes encompass not only the abilities to speak, write, or use various media (c.f. Table **1**), but are also more comprehensive and complex (Altabbaaa *et al*., 2019; Gey *et al*., 2024; Losier, 2009). Altabbaaa *et al*. (2019) proposed a multidimensional communication scheme for members of interprofessional teams that incorporates dimensions of physiology, tonality, and language, as well as individual perceptions, (mis)interpretations, and filters, also highlighted by Besley and Dudo (2022). All these are standpoints of Neurolinguistics Programming, NLP (*e.g.*, Losier, 2009).

Alfred Korzybski (1879-1950) was the creator of General Semantics and founder of the Institute of General Semantics in Chicago (USA). Korzybski's concept "The Map is not the Territory" discloses that human language is incapable of conveying the complexity of the world, and that whatever we perceive is only an individual insight of the whole (Adler, 2017; Losier, 2009). The way people capture reality is through the senses. Therefore, individual perception is an interpretation of reality based on personal beliefs and values. In other words, when several people face the same reality, such as environmental or sustainability issues, the way it is assimilated or interpreted varies from person to person. The Korzybski approach to semantics has been applied in diverse engineering and scientific management contexts, as well as organizational behavior, linguistic analysis of business processes, and in creating a problem-solving model (Ćwiklicki, 2010). It is also known that Korzybski is one of the main influences on the early development of Neurolinguistic Programming (NLP), particularly the metamodel (*e.g.*, Adler, 2017). This model suggests that everyone has unique filters, intrinsic to our individuality, which shape our interpretation of the world and our response to various situations. NLP concepts are widely used to explain communication barriers and (hidden) phenomena (Losier, 2009).

Communication requires cognitive competences that stand in the proper use of a 'range of mechanisms' (*e.g.*, perception, attention, memory, language, decision-making, reasoning, *etc*.) which control information processing, or more precisely, knowledge acquisition, development, and transformation (*e.g.*, Gey *et al*., 2024).

3.2. Overview of Communication, Collaboration, Problem Solving, and Sustainability. Trends in Higher Education

The pursuit of a sustainable world depends on finding

innovative solutions to problems, which in turn require an integration of knowledge from diverse fields (Batool *et al*., 2023; Brynielson *et al*., 2017; Chaudhuri *et al*., 2023; Hartley and Cotton, 2008; Evans, 2015). Engineers are educated to solve problems using math, science, and technology, and need to be creative, with the ability to tune in to multiple fields of knowledge and stakeholders. When jointly facing an issue, reaching and describing a shared vision, and listing common goals are crucial to finding solutions; effective communication skills are also required (Kalinauskaite *et al*., 2021). Atwood and Pretz (2016) demonstrated that "creativity is not appropriately taught or rewarded" in engineering education. This disregard should not occur, as the ability to think creatively, accept information and resources from other areas of knowledge, and engage with diverse stakeholders is linked to problem-solving and is a valuable skill for addressing environmental challenges.

Although by tradition, communication has not been a primary focus in the context of technical and engineering training, there are emerging trends towards changing this status. Various studies have focused on the need for cross-cutting competencies in higher education, as well as education for sustainable development (*e.g*., Anholon *et al*., 2024; Arbuzova and Alexandrova, 2024; Desha *et al*., 2019). It is also recognised that collaboration and communication stand side by side (Altabbaaa *et al*., 2019; Kwame and Petrucka, 2021; Wüthrich, 2023).

Crawley *et al*. (2011) evaluated the knowledge, skills, and attitudes that graduating engineers should possess, considering communication as having a personal dimension that includes communication strategy and structure, as well as the use of four common media: written, oral, graphic, and electronic. In addition, Crawley *et al*. (2011) recognize the relevance of interpersonal communication and relational skills, such as effective listening, negotiation, and advocacy. Anholon *et al*. (2024) provide insights on integrating corporate sustainability knowledge into undergraduate programs. The work focused particularly on Sustainable Development Goals (SDG) 7, 9, and 13, and "transparent communication" was identified as one of the tools required for achieving sustainability.

Rethinking and redesigning the content of education curricula, as well as bringing innovation to teaching approaches, is a concern of educators and professors (*e.g*., Arbuzova and Alexandrova, 2024; Imran *et al*., 2024; Gey *et al*., 2024; McCollum *et al*., 2020; Passow and Passow, 2017; Vivekananth *et al*., 2023). Table **2** lists examples of cross-cutting competences. In selecting these competencies, a combination of criteria was applied: frequency of mention in relevant academic and policy literature, authority and credibility of the sources, and alignment with the three key dimensions of communication –technical, interpersonal, and strategic. This integrative approach ensured that the identified competencies reflect not only prevalence and expert endorsement but also a comprehensive perspective on the types of communication required for effective transdisciplinary collaboration.

Table 2. Competences related to communication and collaboration, identified as relevant for education in environmental, sustainability, or engineering contexts.

Cross-cutting competences related to communication, collaboration, and problem-solving/creative thinking	Source
The authors presented a list of knowledge, competencies, and skills related to education for sustainable development. The skills were collected from sources that analyzed competences in accordance with four focuses: general, pedagogy, management, and engineering. Examples of cross-cutting skills are: • General: o Prospective and creative thinking o Relational competences o Self-knowledge • Pedagogy: o Interdisciplinary work o Critical thinking and analysis o Interpersonal relations and collaboration o Empathy and change of perspective o Strategic action • Management: o Emotional intelligence o System orientation o Action skills • Engineering o Ability to solve problems (integrated resolution) o Ability to work in an interdisciplinary group (collaboration) o Critical thinking o Self-knowledge competence	Anholon *et al*. (2024)

(Table 4) contd.....

Cross-cutting competences related to communication, collaboration, and problem-solving/creative thinking	Source
The capacity for creative thinking and the ability to integrate knowledge and resources from diverse disciplines and stakeholders are closely associated with effective problem-solving, a skill of particular importance in environmental sciences. In this context, a new course unit titled "conscious and co-creative communication" has been designed to foster communication competencies among environmental sciences and engineering students. The targeted competencies to be developed through this course are as follows: • Effectively and consciously manage communication processes. • Communicate clearly and effectively with diverse audiences, including policymakers, journalists, and members of civil society. • Use creative communication strategies in multicultural and interdisciplinary contexts. • Leverage communication as a tool to support and inform decision-making processes. • Contribute to innovation and the integration of knowledge across different domains through effective communication.	Barbosa (2023)
Communication competences are considered to have two dimensions, personal and interpersonal, as follows: • Personnel communication skills o Writing o Oral presentations o Graphics • Interpersonal communication skills (aligned with UNESCO Learning to Live Together, 2023) o Inquiry, Listening, and Dialogue o Negotiation, Compromise, and Conflict Resolution o Advocacy o Establishing Diverse Connections and Networking	Crawley *et al*. (2011)
Cross-cutting competences and capacities recommended to be included in education for sustainable development are: • Creative thinking • Communication • Collaboration, cooperation • Participation • Respect	Gey *et al*. (2022)
The authors clearly state that solving problems is the core of engineering practice. Their study identified the eight competencies that differentiate between outstanding and ordinary performance (of engineers) as being: • Communicate effectively • Coordinate efforts • Take initiative • Gather information • Define constraints • Think creatively • Make decisions • Devise process	Passow and Passow (2017)

The information included is intended to demonstrate how cross-cutting skills related to communication are being emphasized. This evidence points out that (higher) education organizations need to acknowledge the relevance of communication and should address it based on an eclectic grasp of all its dimensions, including impacts on collaboration, problem solving, and innovation towards sustainability.

3.3. Results from the Search for Communication Topics in Higher Education

3.3.1. The European Context

A clear objective guided the search on Master's Programmes in Environmental Sciences in Europe, to find training in the broad concept of environmental sciences. This search returned 80 results, including several master's programmes with a very specific focus, such as the MSc in "Aquatic Science and Technology" (Technical University of Denmark) or the MSc in "Arctic Mineral Resources" (Lulea Technical University). To ensure alignment with the study objectives, only the curricula of master's programmes whose title included the terms "environmental sciences/ studies/ engineering" and/or contained the words "sustainability" and/or "management" were relevant.

Based on this criterion, the 80 results were screened, leading to a subgroup of 18 master's degrees, each of which was subjected to individual analysis. The universities and countries corresponding to these 18 cases are presented in Table **3**, ensuring a comprehensive and reliable selection process.

The four countries with more than one master's degree that accomplished the requirements are Sweden, with 3 degrees, and France, Italy, and Norway, with 2 master's degrees. The evaluation of the available online programmes did not identify any subjects related to communication. The only pertinent finding was the Communication Project unit offered by the master's program in Environmental Engineering and Management

at ISIGE - Mines ParisTech (France). This unit is included within "Complementary Modules" and states that, "*Communication is an important issue for raising awareness, motivating, and convincing the various stakeholders during the implementation of an environmental or SD project. The aim of this module ... is to get students of various profiles (engineers, GSE masters, journalists, managers, academics) to work together to research and produce communication objects aimed at providing reliable information for the general public*". (ISIGE - MINES ParisTech, 2022).

3.3.2. The USA Context

The equivalent search (Master's programmes in Environmental Sciences, 2022) in the USA returned 31 results. The designations of these academic programmes allowed for the inference that some of the master's degrees have a very specific focus, such as the MSc in "Soil Science" at North Dakota State University or the MSc in "Marine, Atmospheric and Geosiences" at the University of Miami Rosenstiel School, among others. The list of universities offering these master's degrees is presented in Table **4**.

Table 3. European Universities having master's degrees with names including "environmental sciences"; "environmental studies"; "environmental engineering", "environmental sustainability", or "environmental management".

University	Country
• Ghent University	Belgium
• The Cyprus Institute	Cyprus
• Graduate School of Agriculture and Bioengineering Lille • ISIG Mines ParisTech	France
• Eötvös Loránd University Budapest	Hungary
• Trinity College Dublin	Ireland
• Ca' Foscari University of Venice • Mediterranean University of Reggio Calabria	Italy
• Norwegian University of Life Sciences • University of South-Eastern Norway	Norway
• Warsaw University of Technology • Cardinal Stefan Wyszyński University in Warsaw	Poland
• Umeä University • Lund University • Stockholm University	Sweden
• University of Lausanne	Switzerland
• University of Groningen	The Netherlands
• Open University, Milton Keynes	United Kingdom

Table 4. USA Universities having master's degrees with names including "environmental sciences"; "environmental studies"; "environmental engineering", "environmental sustainability", or "environmental management".

University	Location
• Boston University Graduate School of Arts and Sciences	Boston
• California State University, San Bernardino College of Natural Sciences	San Bernardino
• Christopher Newport University	Newport News
• Colorado State University College of Veterinary Medicine and Biomedical Sciences	Fort Collins
• Florida International University – College of Arts, Sciences & Education	Miami
• Gannon University[1]	Erie
• Georgetown University – Graduate School of Arts & Sciences	Washington
• Johns Hopkins University, Advanced Academic Programs	Baltimore
• Lehigh University	Bethlehem
• Lincoln University of Missouri College of Agricultural, Environmental and Human Sciences~	Jefferson City
• Lincoln University of Missouri College of Arts & Sciences	Jefferson City
• Murray State University	Murray
• New Jersey Institute of Technology	Newark
• New Mexico State University[2]	Las Cruces

(Table 4) contd.....

University	Location
• North Dakota State University - Graduate School	Fargo
• Prescott College	Prescott
• Rochester Institute of Technology	Rochester
• Stockton University	Galloway
• Tennessee State University	Nashville
• Tufts University – Graduate School of Arts and Sciences	Medford
• The George Washington University – Columbian College of Arts & Sciences	Washington
• University of Illinois Springfield	USA online
• University of Illinois at Urbana-Champaign – College of Agricultural, Consumer and Environmental Sciences	Champaign
• University of Miami Rosenstiel School	Miami
• University of New Haven	Connecticut
• University of South Florida St. Petersburg – College of Arts & Sciences	Saint Petersburg
• University of Texas at Arlington	Arlington

The universities' online curricula were analysed. No course topic with affinities to the theme of communication was identified in any of the master's programmes.

McCollum *et al*. (2020) examined methods for teaching technical communication in accredited undergraduate environmental engineering programs in the USA. They evaluated approximately 10% of the 98 available programs. Among the nine universities analyzed, five included some form of communication skills education, primarily focused on developing competencies such as writing or advanced writing (*e.g*., Bucknell University and the University of Southern California), as well as a course titled "Engineering Design and Communication" (McCollum *et al*., 2020). Although this information pertains to undergraduate education rather than master's degrees, it is presented here as somewhat relevant to the search findings.

3.3.3. Other Courses and Training Offered by Universities across Europe and the USA

The results obtained through the Google engine enabled the identification of a summer course and three communication tutoring or training courses.

The Johns Hopkins Whiting School of Engineering, USA (2022), offers a summer "Communication of Environmental Information and Stakeholder Engagement" course. The course description mentions "*the importance of clear communication of complex scientific information for the development and acceptance of technologies, public policy, and community-based environmental initiatives*". It also states, "*The emphasis of the course is from the point of view of an environmental professional and developing an effective science-based communications portfolio to share complex scientific information with a broad range of interested parties*."

The other findings regarding communication support or training in the technical academic context are from the College of Engineering at Northeastern University (USA) and the Massachusetts Institute of Technology (MIT, USA).

Northeastern University offers a Programme in Communication (written and oral), facilitated through resources provided by the alumni and academic staff of the Department of Civil and Environmental Engineering. Their purpose was to ensure that "*Northeastern's civil engineering graduates, having high analytical and problem-solving skills, could reach their full professional potential by including formal training in communication*" (Civil and Environmental Engineering Northeastern, 2022).

The Communication Fellows at the Massachusetts Institute of Technology (MIT, USA) are a trained team of graduate students and postdoctoral fellows. This group offers engineering students support in "*learning universal communication best practices and strategies for success, specifically in civil and environmental engineering*" through Communication Labs (MITCommLab, 2022).

The search identified the online training "Communicating for Influence and Impact", offered by the Institute for Sustainable Leadership at the University of Cambridge (UK). This 8-week course aims to enhance communication to inspire others, facilitate innovation, promote sustainability, and drive positive organizational changes (University of Cambridge, 2022).

4. DISCUSSION

The initial expectation was to find a significant integration of communication training, especially covering broader interpersonal and strategic dimensions, in environmental master's curricula. However, the findings revealed a stark contrast. Only isolated cases, such as ISIGE-Mines ParisTech in France or the Johns Hopkins summer course in the USA, include broader communication approaches. This discrepancy highlights a gap between what current literature recommends and what curricula deliver.

[1]Offers two MSc accomplishing the search criteria: MSc in Environmental Health & Safety and MSc in Environmental Management.

[2]Offers two MSc accomplishing the search criteria: MSc in Plant and Environmental Science and MSc in Water Science & Management. The last one although not explicitly referencing the term "environmental," was included due to its focus on "water," a subject intrinsically linked to multiple environmental dimensions.

The outcomes provided by the search for master's degrees offering training in communication were meant to be qualitative and are limited to Europe and the USA. Another limitation is that online information on programs varies in detail across universities. The results were provided by a single database, which may guarantee similar criteria for the selection and listing of the courses from European and US universities. However, it was noted that master's degrees offered by Portuguese universities are not included in this database, indicating incomplete records. As an evaluation of what findings could be brought by a country-specific search, an additional investigation was carried out on the websites of twelve (12) universities and five (5) polytechnics[3] where environmental-related MSc courses are taught in Portugal. These higher education organizations provide training in engineering and/or environmental-related sciences, represent all regions of the country, and are the most well-known universities and polytechnics. The only reference to communication was found in the Faculty of Sciences and Technology from the NOVA University of Lisbon (FCT NOVA, 2022), which has a curricular unit named "Sustainability of Organizations". This subject includes among its objectives "Written and oral communication skills and teamwork". The results suggest that, although Portuguese masters are not included in the database used for the search, the findings from analyzing a significant sample of MSc students from this country are in line with the initial results. Also noteworthy is that evaluating countries individually is time-consuming and not a feasible option for global evaluations. Even McCollum *et al*. (2020) in their study, conducted in a country-based context, the USA, used a sample of 10% of the accredited universities to gain an overview of technical communication across environmental engineering programs.

To improve the interpretability of the findings, Table **5** presents a matrix that systematically categorizes the universities by country, based on the inclusion of any form of communication training, ranging from foundational writing skills to more specialized communication competencies.

Therefore, despite the limitations of the search, it is considered that the overview of Master's Curricula from Europe and the USA, combined with the outcomes from the Google search on other training at the academic level, suggests that there is not a broad academic offer of communication education within environmental studies or engineering master's. The literature overview presented corroborates this understanding.

The motivation of the ISIGE - Mines ParisTech for the Communication Project, and the willingness of the Johns Hopkins Whiting School of Engineering (USA) to train students to communicate with different target audiences, such as scientists from various fields, decision-makers, and society in general, is of utmost value and validates the motivation of the present work. The Johns Hopkins Whiting School of Engineering's premise that the course is designed to serve environmental science professionals, not communication or marketing professionals, is pertinent to the motivation of this study. These results also validate the premise that technical degrees in civil and environmental engineering are recognized as requiring communication skills training.

Table 5. Matrix of European and USA universities offering academic programs or other types of communication training.

University	Country	Type of Communication
ISIGE - Mines ParisTech	France	Project-based, strategic for stakeholders' engagement
New University of Lisbon	Portugal	Written and oral skills
University of Cambridge	United Kingdom	Short course – Communication for leadership & inspiration
Johns Hopkins Summer Course	USA	Science-based, stakeholder engagement
MIT Comm Lab	USA	Technical (support labs)
Northeastern University	USA	Written and oral (technical) Engineering Design and Communication *
Bucknell University*	USA	Writing course
University of Southern California*	USA	Writing and Critical Reasoning
Georgia Institute of Technology*	USA	English (no technical communication)
Missouri University of Science and Technology*	USA	Exposition and Argumentation
United States Military Academy (West Point)*	USA	Composition and Literature

* Data from McCollum *et al*., 2020.

Communication fellows at MIT are primarily focused on producing information materials, such as writing and presenting scientific and technical information. As previously elaborated, these constitute a portion of communication; if only this dimension is explored, communication becomes restricted and does not fully support collaboration and problem solving.

The absence of structured communication training in environmental and engineering curricula has significant implications. Without this foundation, graduates may lack the interpersonal, intercultural, and strategic communication skills to engage stakeholders, resolve conflicts, and collaborate across disciplinary boundaries. This gap weakens the ability to co-design and implement sustainable solutions, as technical proficiency alone is insufficient to navigate the complexity of real-world environmental challenges.

[3]All of them are public institutions.

CONCLUSION

This work provided insights into the importance of understanding the broad dynamics of communication, distinguishing between personal and interpersonal skills. The search results confirmed the existence of interconnectedness among communication, collaboration, creativity, and problem solving. There is a growing consensus in academic literature that communication is a foundational skill for sustainability education, not merely an auxiliary one. Recent studies in engineering, environmental sciences, and education policy have emphasized the integration of strategic, interpersonal, and co-creative communication into curricula to prepare students for the complexity of real-world challenges. Embedding such competences aligns with global education trends, including UNESCO's Education for Sustainable Development framework, and is essential for shaping resilient, collaborative, and innovative professionals.

This research confirms a pressing need to embed broader technical, interpersonal, and strategic communication competencies into environmental and sustainability curricula. Changes towards valuing the roles of communication, cognition, creativity, and problem-solving could promote interesting educational adjustments with added value in building societal resilience. The novelty of this work lies in framing communication as a systemic enabler of innovation, stakeholder alignment, and societal resilience. Universities should consider implementing modules such as “Conscious and Co-Creative Communication”, “Collaborative Science Communication”, or “Strategic Engagement in Sustainability” within master's programs. These could benefit from interdisciplinary formats and project-based learning to enhance real-world readiness.

STUDY LIMITATIONS

While this study focused on master's programs in Europe and the United States, this was a strategic decision based on the accessibility and consistency of data within these regions, as well as their longstanding engagement with environmental sustainability in academic and policy contexts. However, we recognize the value of a broader international analysis. Future research should aim to incorporate programs from Asia, Latin America, and other underrepresented regions to provide a more globally balanced perspective on communication training in environmental and sustainability education.

AUTHOR'S CONTRIBUTIONS

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

DECLARATION

The grammar and readability of the article were improved using Grammarly.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used in this research.

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