

GreenEDU: designing green competences by GreenEDU strategy and open digital curriculum in HEIs

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Abstract

The GreenEDU project addresses the urgent need for green skills and sustainability competencies in higher education by developing a comprehensive strategy and digital toolkit for educators, leaders and stakeholders. Through a collaborative, multi-country partnership, GreenEDU leverages design thinking, universal design and stakeholder engagement to co-create accessible resources and embed sustainability into institutional practices. This paper presents the project's objectives, methodology, partnership, and key results to date, highlighting its relevance to the digital transformation and sustainability themes of the advanced information systems engineering. The project's open-access outputs and inclusive approach aim to bridge the gap between higher education and the evolving demands of the green economy.

Keywords

Green Economy, Higher Education, Augmented Reality (AR), Digital Escape Rooms, Information Systems Engineering, Gamification

1. Introduction

The transition to a sustainable, green economy requires a workforce equipped with new competencies, so-called "green skills", that enable individuals and organizations to address environmental challenges, foster innovation, and support the European Green Deal. Higher education institutions (HEIs) play a pivotal role in this transformation by embedding sustainability into curricula, teaching practices, and institutional strategies. The European Green Deal emphasizes the necessity of climate neutrality by 2050, a goal that demands radical shifts in industrial practices, policy-making, and, crucially, education. Higher Education Institutions (HEIs) serve as the primary engine for high-level skill acquisition; yet, research indicates that traditional academic structures often struggle to integrate the rapid technological shifts associated with the green economy [6, 7, 9].

The GreenEDU project responds to this need by developing a comprehensive strategy and digital toolkit to support HE educators and leaders in integrating green skills into their programs and operations. It was initiated in response to the growing recognition that sustainability and green skills are essential for future-ready graduates and institutions. GreenEDU was conceived to address this "skills gap" by providing HE educators with free, open-source digital resources. By leveraging Information Systems (IS) such as Augmented Reality and digital gamification, the project seeks to transform abstract environmental concepts into tangible, immersive learning experiences [6, 7].

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The project brings together six partners from four European countries, each contributing expertise in education, digital innovation, sustainability, and stakeholder engagement. The consortium's collective experience ensures a robust, context-sensitive approach to curriculum development and capacity building.

The main purpose of GreenEDU is to: (1) design a GreenEDU Higher Education Strategy as a foundation for embedding green skills and sustainability across HEIs; (2) develop an open-access, digital e-Toolkit containing guidelines, theoretical materials, and practical resources for educators, leaders and stakeholders; (3) ensure universal accessibility and inclusiveness in all project outputs, following Universal Design for Learning (UDL) and Web Content Accessibility Guidelines (WCAG) 2.2; (4) engage a broad range of stakeholders—including individuals with disabilities, policymakers and industry representatives—in the co-creation and validation of project resources; (5) disseminate project results widely through digital platforms, social media, academic events and strategic partnerships.

The project responds to: the urgent need for HE to address climate change and sustainability challenges, the lack of structured, accessible, and inclusive frameworks for green skills development in HE and fragmented approaches to sustainability in curricula and limited engagement with stakeholders, including students, educators and industry [10].

A comprehensive needs analysis identified: insufficient integration of green skills in HE curricula, gaps between HE outcomes and labour market requirements for the green economy, limited use of digital and AR technologies in sustainability education, as well as barriers to accessibility and inclusion in existing resources, insufficient stakeholder engagement, particularly with underrepresented groups and industry partners, and lack of digital tools and universal design principles in sustainability education. The project aims to address these gaps by creating a unified, accessible and stakeholder-driven approach to green skills development in higher education.

The GreenEDU Consortium contains six partners. Their roles and duties in the framework of the project are as follows:

1. Technical University of Lodz (Poland): supports research, stakeholder engagement and academic dissemination.
2. University of Nicosia (Cyprus): leads the design of the GreenEDU Strategy and provides guidelines, templates and administrative support.
3. University of Tartu (Estonia): lead on dissemination, leveraging 15 years of experience in outreach via workshops, conferences, publications and media.
4. VIVES University of Applied Sciences (Belgium): focuses on outreach to schools, environmental organizations and governmental agencies, specializing in the pedagogical application of immersive technologies.
5. INNOVADE (Cyprus): responsible for the design and development of the GreenEDU e-Toolkit and digital platforms, focusing on the technical design and development of gamified learning resources
6. CleverMind (Poland): leads the development of the Green Action Plan for sustainable project execution.

All partners contribute to stakeholder engagement, content development and quality assurance through the Project Steering Committee and national GreenEDU Committees. Full project name is GreenEDU – Closing the gaps between HE and the green economy.

The paper is structured as follows: Section 2 presents the objectives, methodology and expected tangible outputs of GreenEDU project. Section 3 describes the Green education curriculum – comprehensive framework for green skills in higher education developed for HEIs in the framework of GreenEDU while section 4 deals with GreenEDU project issue relevance to advanced information systems engineering.

2. Project objectives, methodology and expected tangible outputs

The European Green Deal and the United Nations Sustainable Development Goals (SDGs) have set ambitious targets for climate action, resource efficiency, and social inclusion. However, a significant

gap exists between the skills required by the green economy and those currently developed in higher education. Employers increasingly seek graduates with sustainability competencies, yet HEIs often lack structured frameworks, resources, and strategies to embed these skills across disciplines [1, 2].

The main GreenEDU project objectives are as follows:

- Design a GreenEDU Higher Education Strategy as a foundation for embedding green skills and sustainability across HEIs to build the capacity of HE staff to develop and implement the Green Higher Education Action Plan.
- Build the capacity of HE students to acquire green skills and sustainability competencies for the labour market.
- Develop an open-access, digital e-Toolkit containing guidelines, theoretical materials and practical resources for educators, leaders and stakeholders.
- Engage a broad range of stakeholders—including individuals with disabilities, policymakers and industry representatives—in the co-creation and validation of project resources – establish robust networks with stakeholders, including HEIs, industry, policymakers, and students, for ongoing use and exploitation of project materials.
- Integrate project outcomes into standard HEI policies and practices, ensuring sustainability and long-term impact.

The methodology of GreenEDU include the following approaches:

- Design thinking: user-centered, iterative development of the Action Plan and e-Toolkit.
- Stakeholder engagement: National GreenEDU Committees (at least 10 stakeholders per country), field research with 200+ participants and ongoing consultation.
- Universal design and accessibility: all outputs follow UDL and WCAG 2.2 standards, with direct involvement of individuals with disabilities.
- Monitoring and evaluation: regular assessment of project impact, effectiveness and partner satisfaction.

The GreenEDU methodology is grounded in the design thinking process, ensuring that all activities are user-centered, iterative and collaborative. Key steps include: drafting and refining the GreenEDU Strategy through partner feedback and stakeholder consultation, establishing national GreenEDU Committees with at least 10 relevant stakeholders per country, conducting desk and field research, including consultation meetings and data gathering with at least 200 stakeholders across all countries, as well as synthesizing best practices and stakeholder input to inform the e-Toolkit and strategy documents [6, 7, 8].

A particular emphasis is placed on accessibility and inclusion. All materials are developed following Universal Design, UDL, and WCAG 2.2 standards. The project ensures: involvement of individuals with disabilities in resource creation, accessible events and digital materials, and transparent feedback channels for continuous improvement.

The main activities contain: desk and field research on green skills needs and best practices; development of the GreenEDU Strategy and Action Plan; creation and piloting of the GreenEDU e-Toolkit (including gamified features and AR technology for HE); translation and localization of materials into partner languages; dissemination through conferences, workshops, academic publications and digital platforms; exploitation planning for integration into HEI policies and long-term sustainability.

The central mission of GreenEDU is to empower HE staff and students through four primary technological and strategic pillars:

1. Work Package 2: GreenEDU HE Strategy and e-Toolkit

- The objective is to design a "stepping stone" for HEIs to modernize their sustainability approach.

- Output: an online e-Toolkit featuring guidelines for educators to successfully improve students' green skills, with desk and field research involving 200 stakeholders, the establishment of national committees and a collection of best practices for sustainable waste management education.

2. Work Package 3: AR Technology Curriculum

- This package focuses on the "Digital" side of the twin transition.
- Output: GreenEDU AR Curriculum and Learning Design Framework that equips educators with a list of Mobile Augmented Reality Games (MARG) and instructions on how to use them in lesson plans to promote environmental problem-solving.

3. Work Package 4: Digital Escape Rooms and Animation

- The purpose is to increase student engagement, utilizing GreenEDU gamification.
- Digital resources capturing six Digital Escape Rooms and six informational animation videos to cover topics such as green skills in the labour market and how various HE degrees (STEM, Business, Humanities) contribute to the green economy.

3. Green education curriculum: comprehensive framework for green skills in higher education

The works presented in the paper are located in the intersection of sustainability, education and labour markets. This results in a critical and complex relationship between skills provided by higher education and the needs of the labour market, especially in the context of the green transition. All partner countries report skill deficiencies and which results in elevated unemployment rates with higher education degrees or need for upskilling or reskilling. The HEIs and industry thus need to collaborate closely to provide training pathways that transform existing jobs to green(er) versions by equipping workers with new technical and sustainability-related competencies [5]. The factors contributing to this gap are multi-dimensional and are called "wicked problems". The gap spans social, economic, political and environmental issues, which demand equally multifaceted solutions. This reflects in the Quintuple Helix Model of Innovation [1, 2, 5].

The Quintuple Helix Model of innovation provides a framework for integrating green skills into higher education and research. By fostering collaboration among diverse stakeholders, it establishes a shared terminology and set of goals that support collective solutions to complex sustainability challenges, often described as wicked problems. Such challenges are socially interdependent, multifaceted, and perceived differently across disciplines and sectors. By linking the five helices, the model ensures that progress in one domain positively influences the others, thereby encouraging decision-making that extends beyond a single perspective. This interconnectedness supports holistic approach to sustainability and innovation.

Furthermore, the model illustrates how relations between academia, industry, and government evolve across economic contexts. In low-income countries, a static Triple Helix dominates, with actors largely operating in isolation. Middle-income countries often display a laissez-faire version, with limited interaction beyond essential needs. In contrast, high-income countries foster an interactive Triple Helix, characterised by close collaboration, hybrid organisations, and a more entrepreneurial role for universities. Building on this, the Quintuple Helix incorporates societal and ecological dimensions, embedding sustainability more firmly within innovation systems [1, 3, 4].

The transition towards a green economy requires integrated progress across all dimensions of sustainable development. Central to this process is the notion of a just transition, which emphasises fairness, inclusivity, and social equity. A just transition seeks to align climate action with the creation of decent work opportunities and the principle of leaving no one behind. This involves maximizing the social and economic benefits of green transformation while minimising potential risks, ensuring that challenges are managed responsibly. Achieving this balance depends on social dialogue with affected stakeholders and adherence to fundamental rights and labour standards [3, 5].

Building on the principles of a just transition and the Quintuple Helix Model of innovation, there is a growing need to design an integrative framework that can address all domains of sustainable development and provide guidance in tackling "wicked problems". Such a framework should move beyond fragmented approaches and foster systemic thinking, interdisciplinary collaboration, and innovation. By embedding these dimensions into higher education, students can be equipped with the skills, competencies, and critical perspectives necessary to navigate and contribute to a just transition economy. This includes not only technical expertise but also the ability to engage in ethical reasoning, collective action, and adaptive problem-solving in rapidly changing socio-ecological contexts.

The development of green mindsets, including technical skills and value-driven attitudes, is essential. The HEIs must go beyond technical training and embedding green values and attitudes to prepare graduates who can lead sustainable change. The most prominent and relevant framework for the integration of green skills in higher education institutions (HEI) in several European countries is the European Green Skills Competence Framework, also known as the GreenComp framework (European Commission, 2022). This is a European framework that focuses on developing the specific sustainability competences needed for the green transition.

The GreenComp has 12 competences, distributed over 4 areas. The first area is Embodying Sustainability Values, which contains (1) Valuing sustainability, (2) Supporting fairness and (3) Promoting nature. A second area is Embracing Complexity in sustainability with the following competences: (4) Systems Thinking, (5) Critical Thinking and (6) Problem Framing. The next three competences are (7) Futures literacy, (8) Adaptability and (9) Exploratory thinking, covered in the third area Envisioning Sustainable Futures. The last area is Acting for Sustainability, with (10) Political agency, (11) Collective action and (12) Individual initiative.

Other useful frameworks are:

- EU Council Recommendation on learning for the green transition. This recommendation guides policy and investment, as well as best practices for integrating these skills into education and the workforce. There are various national or regional roadmaps based on this Recommendation [6].
- EntreComp for Transition. This framework elaborates on the EntreComp framework (the European Entrepreneurship competence framework), but strongly focuses on the green and digital transitions (which is the core of our project). EntreComp for Transition emphasises agency, innovation and co-creation [2, 7, 8].
- Sustainable Development Goals. In the report of Paeradigms [5] about integrating green skills into higher education teaching and research, they start the rationale for greening HEI and HER (Higher Education Research) with frameworks of Planetary Boundaries and Doughnut Economics. Planetary boundaries can be scientific thresholds marking the limits within humanity can safely operate. By adopting the above-mentioned frameworks, HEIs can break down the SDGs into balanced pillars: an environmental, an economic and a social pillar [2, 6].

Integrating sustainable competences (GreenComp) and digital competences for teachers (DigCompEdu) requires a systematic approach in which both frameworks reinforce each other. A high-level model can provide guidance by structuring the intersection of both frameworks into four quadrants: "Values & Engagement (Why)", "Complexity & Didactics (How)", "Action & Tools (What)" and "Transformation & Innovation (Next)". These quadrants describe the logical sequence of values, didactic approach, practical actions and innovative transformation.

Values & Engagement (Why). This first quadrant focuses on the value base. GreenComp emphasises value awareness and the principles of sustainability, while DigCompEdu focuses on professional engagement and empowering learners. Teachers therefore use digital resources not only efficiently, but also in an ethical, inclusive and sustainable manner. This implies that digital literacy cannot be viewed separately from the social responsibility of education to promote sustainable values.

Complexity & Didactics (How). The second quadrant focuses on the pedagogical-didactic approach. GreenComp introduces "systemic thinking", "critical thinking" and "future-oriented thinking". DigCompEdu supplements this with the domains of "teaching & learning" and "assessment". In this context,

digital technologies are used to explore, critically analyse and evaluate complex sustainability issues. This requires teachers to have both didactic creativity and the ability to guide learners in dealing with uncertainty and complexity.

Action & Tools (What). The third quadrant connects values and didactics with concrete actions and instruments. GreenComp emphasises "political agency", "collective action" and "individual initiative". DigCompEdu refers to the use of "digital learning resources" and the "facilitation of digital competences". Here, teachers and students learn how to use specific digital tools to take action, collaborate and develop innovative solutions. The emphasis is on strengthening perspectives for action, both at the individual and collective levels.

Transformation & Innovation (Next). The fourth quadrant focuses on the future-oriented transformation of educational practices. GreenComp emphasises "problem-solving skills", "innovation" and "exploratory learning". DigCompEdu focuses on "digital content creation", "student engagement" and "digital collaboration". This results in a form of "transformative learning", in which new ways of learning and working are developed that explicitly bring together sustainability and digitisation. Education thus functions as a laboratory for innovation and change.

Thus, the four-quadrant model offers a narrative that clarifies how GreenComp and DigCompEdu mutually reinforce each other. By starting from values (Why), moving on to didactic approaches (How), concrete practices (What) and ultimately innovative transformation (Next), an integrated framework for the professionalisation of teachers is created, which leads to fostering the students. This framework supports them in the ethical, critical and creative use of digital technology in the service of a sustainable future.

The new framework, serving as the foundation for the GreenEDU curriculum, is based on several existing frameworks and encompasses multiple competence areas, presented in figure 1.

Translating this framework to a new curriculum, we can distinguish three layers of integration. First of all a pedagogical distinction, where lecturers use digital tools, like AR, to stimulate the development of sustainability competences. A second one is a didactic part, in which learning activities are designed in which digital literacy and sustainability are interwoven. Finally, a curricular distinction to formulate learning goals that explicitly cover the new framework.

We offer a curriculum proposal for integrating Sustainability, Digital Competence and Entrepreneurial Transition Skills to upgrade the green skills for a green economy. The rapid digital and ecological transformations of contemporary society require higher education to rethink its curriculum design. This proposal outlines a three-phase curriculum structure that integrates complementary European competence frameworks. The integration of these frameworks enables learners to progress from awareness and comprehension to transformation and innovation, thereby developing sustainable, digitally literate, and entrepreneurial professionals. Together, these frameworks create a multidimensional perspective that equips learners to engage ethically, act effectively in complex contexts, and foster innovation for sustainable futures. The presented above results are accessible in detail on the GreenEDU website [URL: https://greenedu-project.eu](https://greenedu-project.eu).

4. Relevance to advanced information systems engineering

The GreenEDU project is highly relevant to the topics of advanced information systems engineering, particularly in digital transformation, sustainability, and inclusive education. The project's focus on digital toolkits, universal design and stakeholder-driven strategy aligns with information systems engineering emphasis on innovative information systems, user-centered design, and the societal impact of digital solutions. The open-access, data-driven approach of GreenEDU provides a model for integrating sustainability into information systems engineering and higher education. GreenEDU follows the information systems engineering in the following areas:

- Information systems for sustainability (Green IS) – use of information systems for stakeholder engagement, dissemination and monitoring – GreenEDU represents a practical application of IS to achieve environmental sustainability goals. The project's data-driven approach to identifying

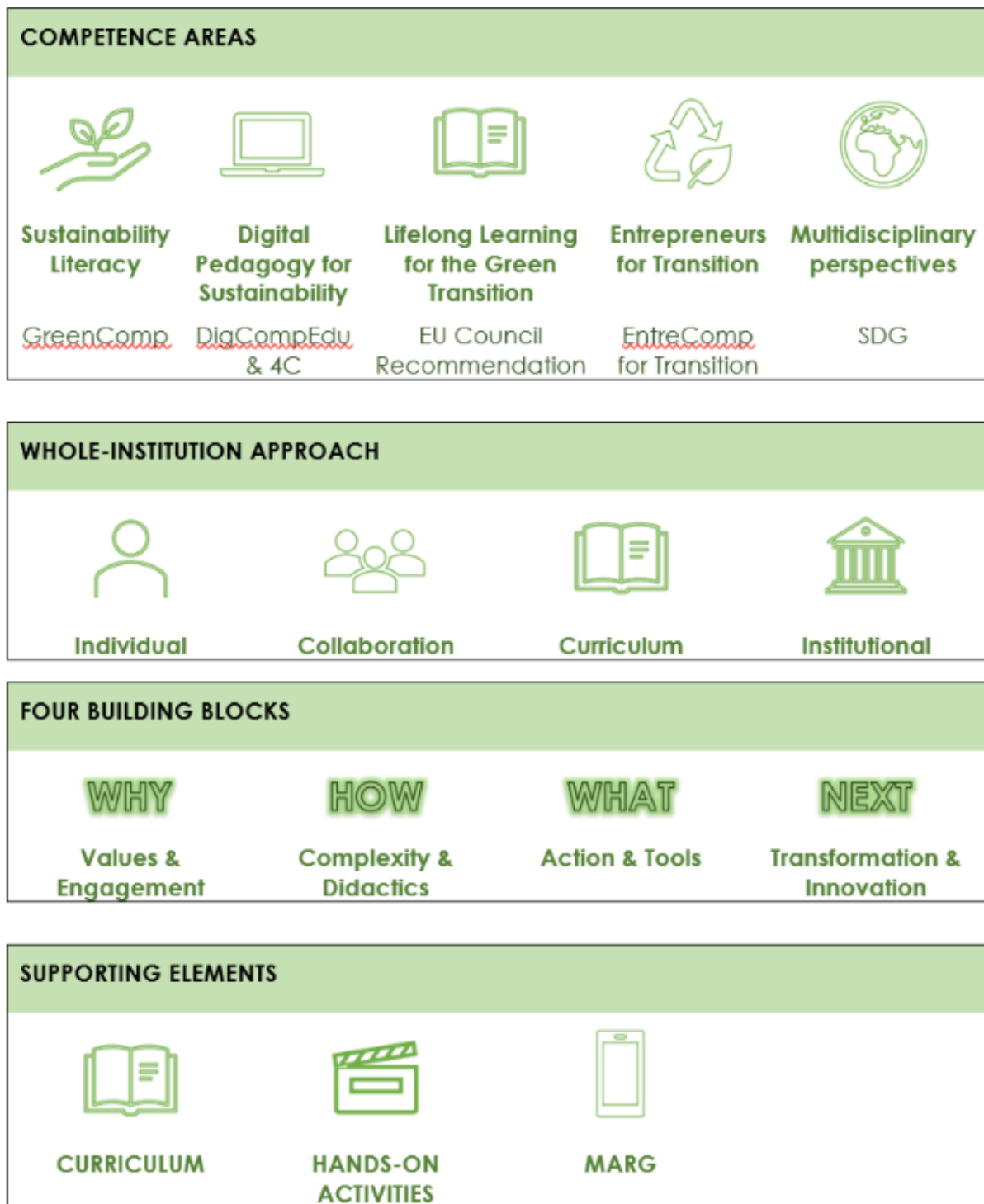


Figure 1: GreenEDU framework curriculum.

skill gaps and its use of digital repositories align with information systems engineering focus on sustainable system design.

- Immersive and interactive Systems – development and deployment of digital toolkits and AR technologies for green skills education – the integration of Augmented Reality (WP3) requires advanced engineering of user interfaces and experience (UI/UX). The mapping of technological affordances to educational objectives mirrors the requirements engineering phase in IS development.

- Gamification and serious games: the development of Digital Escape Rooms (WP4) involves complex logic design and user engagement metrics, central to contemporary IS engineering.
- Information systems in education – integration of universal design and accessibility standards in digital educational resources – the project explores the digital transformation of HEIs, focusing on how cloud-based e-toolkits and collaborative platforms facilitate transnational knowledge management.

5. Conclusions

The GreenEDU project successfully demonstrates that the transition to a green economy can be accelerated through the strategic application of Advanced Information Systems. By combining strategic frameworks (e-Toolkit) with immersive technology (AR) and gamification (Escape Rooms), the project provides a holistic solution for HEIs.

GreenEDU demonstrates the power of collaborative, inclusive, and digitally enabled approaches to embedding sustainability in higher education. By leveraging design thinking, universal design, and broad stakeholder engagement, the project delivers practical, open-access resources that address the green skills gap and support institutional transformation. The project's ongoing results and commitment to accessibility and impact make it a valuable contribution to the fields of information systems engineering and sustainable education.

As we move toward the project's conclusion in November 2026, the focus will shift to long-term sustainability and the translation of materials into national languages. The results obtained by April 2026 indicate a high level of satisfaction among both educators and students, suggesting that the GreenEDU model could be a blueprint for future digital-green educational initiatives across Europe.

The identified challenges and lessons learned during the implementation of GreenEdu project are the following:

- Stakeholder engagement: ensuring broad and meaningful engagement across countries and sectors requires continuous effort and adaptation of communication strategies.
- Accessibility: developing universally accessible materials is resource-intensive but critical for inclusivity and long-term impact.
- Localization: translating and adapting resources to national contexts enhances relevance but requires coordination and quality assurance.
- Sustainability: planning for post-project sustainability and exploitation is essential to maximize long-term benefits.

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Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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