Chapter Five

European Collaboration and Future Sustainability: Interconnections with Other Circular Economy Initiatives

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The Power of Partnership: Cross-Border Cooperation in EDU4PlastiCircular project

The EDU4PlastiCircular project is built upon a robust transnational partnership comprising six key institutions across four European nations: Romania, Slovenia, Spain, and Italy. Figure 5.1 highlights the main

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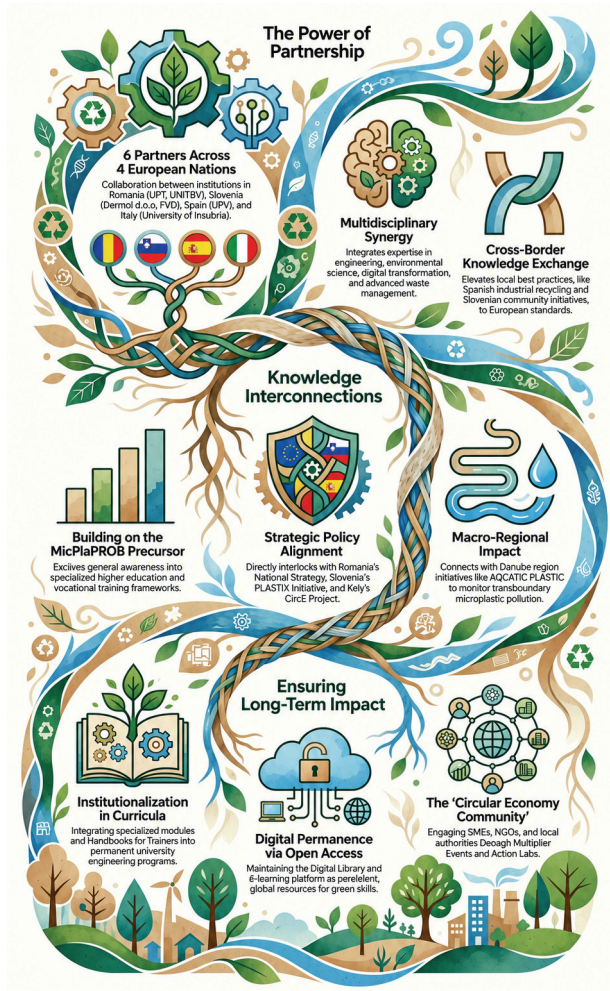


FIGURE 5.1
Overview of the Key Strategic Strengths of EDU4Plasti-Circular Project

NOTES Created by the Generative AI Software NotebookLM.

strengths of the partnership and key sustainability factors on the long term. This geographical and expertise-based diversity is fundamental to the project's ability to address the complex lifecycle of plastics and microplastics through a multidisciplinary lens. This geographical and expertise-based diversity is not accidental. It is a strategic response to the complex, non-linear lifecycle of plastics and the global nature of microplastic contamination. Table 5.1 summarises the strategic contribution and associated roles of each EDU4PlastiCircular consortium members.

The partnership operates on the principle of complementary exper-

TABLE 5.1 Partner Roles and Strategic Contributions

Country	Partner institution	Strategic role and expertise
Romania	Politehnica University Timisoara (UPT)	Leads engineering and technical education initiatives, focusing on sustainable technology development and the integration of circular economy into technical curricula.
Romania	Transilvania University of Brasov (UNITBV)	Provides specialized knowledge in environmental science and engineering, particularly in the assessment of plastic pollution in the Danube region.
Slovenia	Dermol svetovanje d.o.o.	Specialize in digital transformation and professional training, managing the project's E-learning infrastructure and digital pedagogical tools.
Slovenia	Faculty of Environmental Protection (FVO)	Focuses on sustainability education and the development of awareness-raising activities for young people regarding microplastics.
Spain	Universitat Politècnica de València (UPV)	Contributes expertise in advanced recycling technologies and environmental engineering, bridging academic research with industrial plastic management.
Italy	Università degli Studi dell'Insubria	Leads research on waste management and environmental sustainability, focusing on the chemical and biological aspects of plastic degradation.

tise, where the technical engineering capabilities of the Politehnica University Timisoara (UPT) and the Universitat Politècnica de València (UPV) are integrated with the environmental science and protection frameworks provided by the Transilvania University of Brasov (UNITBV) and the Faculty of Environmental Protection (FVO) in Velenje. This interdisciplinary synergy is further enhanced by the digital transformation expertise of Dermol svetovanje d.o.o. and the advanced waste management research conducted by the Università degli Studi dell'Insubria in Italy (Školnik Škrabe et al., 2025).

Cross-border cooperation within this consortium is operationalized through a series of highly integrated joint activities that transcend traditional academic boundaries. A primary example of this is the development of the D2.1 Gap Analysis and Collection of Best Practices, a comprehensive research effort that mapped the plastic management landscape across the four partner nations. This analysis did not merely

identify gaps but also documented successful local circular economy models through a series of 'Good Practice' videos. These videos serve as a repository of practical knowledge, showcasing industrial recycling innovations in Spain, community-led sustainability initiatives in Slovenia, and engineering solutions for waste reduction in Romania. Such collaborative efforts ensure that local best practices are elevated to a European standard, fostering a shared understanding of the circular economy that is sensitive to national specificities yet aligned with broader EU objectives.

Furthermore, the partnership emphasizes vertical cooperation, connecting higher education directly with real-world environmental remediation. The project's collaboration with Blended Intensive Programmes (BIP) has facilitated joint student-teacher initiatives focusing on 'preventing waste ending up into the environment.' These programs, such as the one between UPT and the University of Insubria, combine academic mobility with high-level research on emerging pollutants, allowing students to engage directly with the scientific and social complexities of plastic degradation. This transnational synergy creates a 'European identity' in environmental stewardship, where the collective intelligence of the consortium-manifested through joint publications, transnational meetings in Brasov, Velenje, and Oradea, and the co-creation of digital learning resources, exceeds the sum of its individual institutional contributions.

EDU4 PlastiCircular Knowledge Interconnection with other Projects and Initiatives

Beyond its immediate project lineage, EDU4 PlastiCircular is deeply integrated with macro-regional and national strategies that drive the circular transition in the four partner countries. In Romania, the project aligns with the National Strategy for Circular Economy (2022–2032),[1] which sets ambitious targets for municipal waste recycling. By training the next generation of 'Green Engineers' at Politehnica University of Timisoara (Romania) and Transilvania University of Brasov (Romania), the project provides the human capital necessary to implement these national frameworks. In Slovenia, the interconnection between EDU4 PlastiCircular and other initiatives is particularly strong

[1] More details at https://circulareconomy.europa.eu/platform/en/strategies/national-strategy-circular-economy-romania

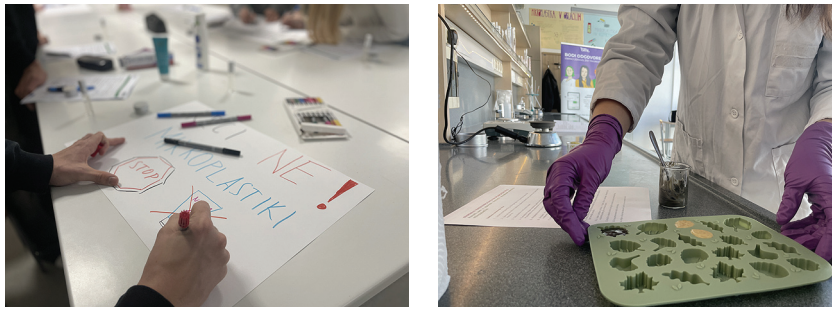


FIGURE 5.2 Hands-on Activities Within the Micro(μ)School program at the Faculty of Environmental Protection in Slovenia

due to the long term strategic focus of the Faculty of Environmental Protection (FVO) on microplastics, harmful substances, and circular economy education. Over the past years, FVO has coordinated or co created several Erasmus+ projects (e.g., MicPlaPROB, GreenGate, GreenGate2), national research activities, and regional awareness campaigns, which together form a coherent knowledge base that directly feeds into EDU4PlastiCircular. A distinctive feature of the Slovenian context is the systematic integration of digital learning environments, open educational resources (OER), and hands on laboratory and field activities (Školnik Škrabe, & Bubik, 2024). Through these approaches, FVO has developed a recognizable educational model that combines scientific accuracy with accessibility for diverse target groups, from secondary school students to university staff, youth workers, and adult learners. The Micro(μ)School programme, developed at FVO, represents one of the most visible outcomes of this interconnected ecosystem. It consolidates knowledge from multiple Erasmus+ projects and national initiatives into a flexible training model that includes workshops on microplastics in textiles, hidden plastics in cosmetics, and basic monitoring techniques for water and soil (Komeriki Kotnik et al., 2025). This model has been repeatedly tested, refined, and expanded, making it a key contribution of Slovenia to the EDU4PlastiCircular partnership.

In addition to educational projects, the project interlocks with the PLASTIX initiative and the SRIP – Circular Economy platform, while also linking with cutting-edge research projects like EMICOPLAST, which explores the use of engineered microbial consortia for plastic degradation. This interconnection ensures that the project's educa-

tional content is not only theoretically sound but also practically relevant to the Slovenian industrial and research landscape. The project's reach extends into the Mediterranean and Danube basins through its alignment with Interreg programs. In the Danube region, EDU4PlastiCircular connects with initiatives such as AQUATIC PLASTIC and MicroDrink, which focus on monitoring and mitigating microplastic pollution in riverine and drinking water systems. These interconnections allow the project to utilize real-world data and case studies on transboundary pollution, providing students with a holistic view of the environmental challenges facing European water bodies.

Similarly, in Spain, the project contributes to national waste management plans like the PEMAR 2025–2035 and regional policy integration efforts like the CircE Project. By weaving these diverse threads together, EDU4PlastiCircular acts as a central hub for circular economy knowledge, synthesizing outcomes from various Interreg, Horizon, and LIFE projects to deliver a curriculum that is both comprehensive and policy aligned.

In Italy the variety of projects is visible under different perspectives: e.g., zooming on the University of Insubria activities, to face with the 'plastic problem,' it emerges the importance of working with an interdisciplinary approach as described below.

The ProPla project (funded by Fondazione Cariplo 2022) is coordinated by Prof. Loredano Pollegioni at the University of Insubria. The research team includes experts from seven units specializing in plastic pollution, enzyme engineering, systems biology, microbiology, entomology, economics, and life cycle assessment. The participating institutions include the University of Milan, the University of Milano-Bicocca, and the Water Research Institute – CNR. The project aims to mitigate the environmental and public health impacts caused by improper plastic disposal, inefficient treatment processes, and the uncontrolled release of microPET. The main objective of the project is to develop an innovative biotechnological application for the removal of PET microplastics (microPET) from wastewater (including treatment plants and household sources such as washing machines and tumble dryers), thereby preventing their release into the environment. The recovered microplastics are enzymatically degraded into their monomers, terephthalic acid (TPA) and ethylene glycol, using an engineered PET-degrading enzyme. Subsequently, TPA is converted into D- or L-alanine by a novel engineered *Escherichia coli* strain. Fur-

thermore, by colonizing the microbiota of the insect *Hermetia illucens* with this engineered bacterium, a biological system will be established for the sustainable valorisation of microPET. The goal is to achieve a paradigm shift: transforming an environmental contaminant, potentially harmful to human health, into a valuable resource to produce useful goods, through a fully sustainable and 'green' approach.[2]

The LIFE CASCADE project (LIFE22 ENV, contract no. 101113942), launched on 1 October 2023 and running for 48 months, focuses on the development, testing, and demonstration of innovative technologies for the removal of two classes of emerging contaminants of particular concern to the textile sector: per and polyfluoroalkyl substances (PFAS) and microplastics. The project aims to evaluate analytical procedures and technological solutions at laboratory scale and validate them at pilot scale, both within textile companies and in centralized wastewater treatment plants. By identifying the most effective combination of treatment technologies, LIFE CASCADE seeks to reduce environmental emissions and promote the reuse of treated water in industrial cycles, while assessing the ecotoxicological feasibility of supplying industrial aqueducts. The consortium brings together 14 partners (besides University of Insubria) with complementary expertise in water treatment, environmental research, and textile innovation. Prof. Antonio Di Guardo, coordinates the activities related to PFAS and microplastics, with a focus on analytical detection, environmental fate, and removal strategies. During the project, prof. Roberta Bettinetti and her team developed a high definition optical microscopy protocol for the quantitative evaluation of microplastics in liquid matrices, enabling accurate characterization of particle abundance and typology. Building on the knowledge generated within LIFE CASCADE, the research team is also carrying out a parallel study on microplastic contamination in Lake Como, examining both sediments and, most extensively, the zooplankton community. These insights contribute to improving environmental management strategies in the context of Circular Economy principles and plastic pollution mitigation.[3]

The AWARE project, funded by the Italian Ministry of University and Research (MUR) in the context of the Italian Science Fund (FIS) 2022–2023, coordinated by Dr. Gilberto Binda, researcher at University of In-

[2] More info at https://www.theproteinfactory2.it/propla
[3] More information can be found at https://lifecascade.eu/

subria, investigates how plastics and their biofilms influence nutrients in the water and plankton communities and explores how they change the properties of sediments, affecting exchanges between the bottom (benthic) and the water column (pelagic), as well as energy transfer at their interface. AWARE aims to provide a new perspective on how plastics are becoming a permanent component of aquatic ecosystems, helping us better predict and manage their long-term environmental impacts.[4]

Given the complexity and relevance of the sector's issues, the University of Insubria has established a Sustainable Fashion Research Center. This center serves as a center of excellence dedicated to the development of innovative solutions for the textile and fashion industries, aiming to accelerate the transition to production models based on the circular economy, resource efficiency, and reduced environmental impact. The Center's activities are based on an interdisciplinary approach that integrates scientific research, technological innovation, and economic model analysis, in close collaboration with businesses, institutions, and creative communities. From this perspective, the Center contributes to the construction of a more sustainable, resilient, and competitive textile supply chain. In the activities (research and education) an integrated attention is dedicated to environmental, economic and social aspects.[5]

The activities carried out within these projects and the associated research initiatives are aligned with the broader objectives of EDU4PlastiCircular, as the project is aimed at integrating research, education, and innovation to promote the adoption of Circular Economy strategies for plastic pollution management.

The EDU4PlastiCircular project is a collaborative initiative involving partners from Romania, Slovenia, Italy, and Spain. These organizations have a long history of implementing European-funded projects (primarily Erasmus+, Interreg, and Horizon) focused on environmental sustainability, circular economy, and waste management.

Table 5.2 present a collection of projects (in the field of research and education, with different financial support and different local/regional

[4] Further information on the project is available at https://www.linkedin.com/in/gilberto-binda-41604ab7/

[5] Information on specific projects can be found at https://www.uninsubria.it/ricerca/strutture-la-ricerca/centri-di-ricerca/centro-di-ricerca-sulla-moda-sostenibile

TABLE 5.2 Projects that Extend EDU4 PlastiCircular Initiative (by Partner Institutions)

Project Title	Type	Brief description	Web page
PLAN-C	Interreg Danube	Focusing on transforming the plastics value chain in the Danube region. Partner Politehnica University Timisoara (RO) and ICMPP co-create circular plastics prototypes.	https://keep.eu/projects/29907
MicPlaPROB	Erasmus+	Awareness of microplastics; digital learning; interdisciplinary SI-IT partnership. Coordinator: Dermol Ltd. (SI), Partner: Faculty of Environmental Protection (SI)	https://microplastics.today/
GreenGate	Erasmus+	Responsible use of cosmetics; harmful chemicals, and adult education. Partner: Faculty of Environmental Protection (SI); with the focus on plastic and microplastic ingredients/packaging	https://green-gate.eu/
GreenGate2	Erasmus+	Youth education on health, environment, and responsible consumption. Partner: Faculty of Environmental Protection (SI); with the focus on plastic and microplastic ingredients/packaging	https://green-gate.eu/
PLASTIX	Interreg Europe	Circular economy transition in plastics; policy improvement; SI region included (Faculty of Environmental Protection)	https://www.interregeurope.eu/plastix
FREINDS	Erasmus+	Developed by Dermol Ltd. (SI) and partners from IT and RO, it creates e-learning courses and gamified digital tools for green skills and environmental awareness.	https://dermol.si/category/eu-projects

Continued on the next page

impact) that has been supported by EDU4 PlastiCircular training programme (by developing the green skills and competencies of different teams' members, in different organizations in Europe), focusing on *circularity, plastics, or environmental management and engineering topics,* that have been developed or implemented by these partners.

More recent, EDU4 PlastiCircular initiative has been expand and impact new projects (developed by partners) specifically focused on *Industrial Symbiosis (IS)* and *Urban Symbiosis (US).* These projects empha-

TABLE 5.2 *Continued from the previous page*

Project Title	Type	Brief description	Web page
CircE	Interreg Europe	An Italian-led project (Lombardy Region) involving Spain and Slovenia to improve regional policies for circular economy in sectors like plastics and textiles.	https://interregeurope.eu/circe
DigiFunCollab	Erasmus+	A collaborative project between partners in Italy, Romania, and Slovenia focused on digital transformation and collaborative learning tools for sustainability.	https://digifuncollab.eu
SymbioTech	Erasmus+	A project implemented by Dermol (SI) and Politehnica Timisoara (RO) aimed at technical education in industrial symbiosis and sustainable technology.	https://dermol.si/category/eu-projects
VIRIDI	Interreg SI-AT	Supporting SMES in Slovenia to adopt greener business models, improved recycling practices, and circular digital platforms.	https://interreg.eu/news-stories
BIOECO-UP	EU Project	A project managed at the University of Ljubljana (SI) focusing on the bio-based circular economy and the upscale of bio-economic value chains.	https://bf.uni-lj.si/en/research

size the exchange of waste, energy, and resources between different industries or between urban centres and industrial zones to close loops (Table 5.3).

The new projects presented in Table 5.3 and the related topic of industrial (and urban) symbiosis are new generation extensions of the EDU4PlastiCircular project outcome (supporting its sustainability, too) because of the following arguments:

- Waste as a resource because these projects and initiatives treat plastic not as waste, but as a secondary raw material that can be transferred from an 'exporter' (e.g., a city's urban waste) to an 'importer' (e.g., a plastic manufacturing plant).
- Multidisciplinary training because like EDU4PlastiCircular, these projects require engineers to understand not just chemistry, but also logistics, legislation, and digital tracking (IOT) to manage the flow of materials between partners.

TABLE 5.3 Projects on Industrial and Urban Symbiosis

Project title	No./ID	Brief description	Web page
EcoNexus	PN-IV-P2-2.1-PED-2023	Led by Politehnica University Timisoara (RO), it develops a digital platform to facilitate Industrial Symbiosis. It uses AI and data mapping to connect resource 'waste' from one company to the raw material 'needs' of another.	https://econexus.upt.ro
CORALIS	Horizon 2020	Focuses on creating real-life pathways for Industrial Symbiosis in energy-intensive industries. Partners in Italy and Spain develop 'IS enablers' to monitor resource flows between plants.	https://coralis-h2020.eu
Symbi	Interreg Europe	Improves regional policies to support Industrial Symbiosis. Involves partners from Slovenia (Governmental Office) and Italy to foster resource efficiency in regional ecosystems.	https://interregeurope.eu/symbi
ACCELERE	Erasmus+	A project involving Politehnica University Timisoara (RO) aimed at accelerating the transition to a circular economy through technical training in Industrial Symbiosis for engineers.	https://accelere.upt.ro

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Regional focus because most of these projects are active in the Italy-Slovenia or Danube (RO) corridors, thus creating a geographic synergy with your current consortium.

Ensuring Long-Term Impact: Establishing the Sustainability of the EDU4PlastiCircular Initiative

Ensuring the long-term sustainability of the EDU4PlastiCircular initiative is a primary objective that is addressed through a multi-layered strategy focusing on institutionalization, pedagogical innovation, and digital permanence. The most significant pillar of this strategy is the institutionalization of project outputs within the permanent curricula of the partner universities. Rather than remaining as a standalone project, the EDU4PlastiCircular modules on sustainable plastic management are being integrated into the core engineering and environmental science programs at UPT, UPV, UNITBV, and the University of Insubria. This integration is supported by the development of spe-

TABLE 5.3 *Continued from the previous page*

Project title	No./ID	Brief description	Web page
SCALER	Horizon 2020	Scaling European Resources with Industrial Symbiosis. It provides a blueprint for European regions (including Spain and Italy) to identify synergy opportunities between diverse industrial sectors.	https://scalerproject.eu
URBANREC	Horizon 2020	A major Urban Symbiosis project led by AIMPLAS (ES). It focuses on the recovery of bulky waste from cities (mattresses, furniture) and converting them into high-value chemicals and fuels.	https://urbanrec-project.eu
T-REX	Horizon Europe	Focuses on the Urban-Industrial nexus for textile recycling. Involves collecting post-consumer urban waste to feed back into industrial manufacturing cycles in Italy and Spain.	https://trex-project.eu
REMADE	Interreg Italy-Slovenia	Promotes the use of recycled materials in the construction sector through Urban Symbiosis, using waste from Slovenian and Italian demolition sites as 'new' raw materials.	https://ita-slo.eu/remade

cialized Training Personas and a comprehensive Syllabus, ensuring that the learning objectives are aligned with the specific needs of students at the Bachelor's, Master's, and PhD levels. The Handbook for Trainers, available in multiple European languages, further facilitates this process by providing local faculty with the tools and methodologies needed to deliver the content long after the project's formal conclusion.

The sustainability of the initiative is further bolstered by its commitment to digital permanence and open access. The Digital Library and E-learning platform serve as persistent resources that remain accessible to the global academic and professional community. By utilizing Digital Badges and certificates, the project provides a recognized framework for the validation of green skills, encouraging lifelong learning and continuous engagement with the project's materials. Additionally, the creation of a 'Circular Economy Community' through Multiplier Events and Action Labs ensures that the collaborative networks established during the project continue to thrive. These events engage a wide range

of stakeholders, including SMES, NGOS, and local authorities, creating a feedback loop where academic research informs industrial practice and societal needs. This community-based approach ensures that the spirit of EDU4PlastiCircular remains a driving force for regional and European innovation in the circular economy for years to come.

Acknowledgments

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Dermol, Š., & Dermol, V. (2024). Exploring online education for circular economy: Content analysis and didactical approaches in plastic waste management courses. *International Journal of Management, Knowledge and Learning, 13,* 209–222.

Draghici, A., Boatca, M. E., Rada, E. C., Perniu, D., Bubik, A., Baera, C., & Sirbu, R. M. (2024). Education for plastic in a circular and climate neutral economy: Preventing waste ending up into the environment. *Acta Technica Napocensis, Series: Applied Mathematics, Mechanics, and Engineering, 67*(Special Issue III), 1105–1114.

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Školnik Škrabe, K., Bubik, A., Dermol, Š., Ferrándiz, S., Perniu, D., Rada, E. C., & Draghici, A. (2025). Educating for sustainable plastic management in a circular and climate-neutral economy. *Journal of Sustainable Technologies and Materials, 8,* 61–66.