Chapter Two

Navigating the Digital Frontier of Plastic Circularity

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https://doi.org/10.53615/978-83-65020-56-7/37-65

Global Trends in Plastic Production and Use

Plastic production has grown exponentially worldwide in just a few decades. *After a steep decline in the first half of 2020 due to COVID-19, production of plastic recovered in the second half of the year and with-it plastic waste. Under the EU Green Deal, 55% of plastic packaging will have to be recycled by 2030.* This implies innovative design, cleaner production and recyclability initiatives build under the circular and neutral economy principles (as supported by PACE latest reports[1]).

Actual facts and statistics about large plastic waste and low recycling/reuse are shown in the official reports of the European Commission[2] and in the last report.[3] It is impressive that Romania and Italy have a recycling rate of 40–50% (lowest rates), Spain of 50–60% and Slovenia more than 70% due to the efforts in education and awareness of the problem. Furthermore, the global challenge of plastic pollution has reached a critical juncture, with world production growing exponentially from *1.5 million tonnes in 1950 to 359 million tonnes in 2018.* Global consumption of plastics has increased *twentyfold in the last 50 years,* and approximately *40% of these materials are used for packaging,* often characterized by a short lifespan and single-use application. This linear 'take-make-waste' model is economically inefficient, as an estimated *95% of the material value of plastic packaging is lost* after just

[1] See https://pacecircular.org/news
[2] More statistics are provided at https://www.europarl.europa.eu/news/ro/headlines/society/20181212STO21610/deseurile-din-plastic-si-reciclarea-in-ue-in-cifre
[3] https://plasticseurope.org/wp-content/uploads/2022/06/PlasticsEurope-CircularityReport-2022_2804-Light.pdf

Dermol, V., Draghici, A., Perniu, D., Bubik, A., Rada, E. C., & Ferrándiz Bou, S. (Eds.) (2026). *The Digital Frontier of Circularity.* ToKnowPress.

one short use cycle. The environmental and climate consequences are equally severe. In 2019 alone, the production and incineration of plastics generated over *850 million tonnes of greenhouse gases,* a figure projected to rise to 2.8 billion tonnes by 2050. A significant byproduct of this pollution is the accumulation of *microplastics,* defined as small plastic pieces *less than 5 mm (0.2 inch) in length.* These persistent particles originate from various sources, including the wear and tear of *paints (unintentional release), tyres, and synthetic textiles.*

Beyond the packaging sector, the *building and construction industry* is a major consumer of plastic, accounting for approximately *6% of total consumption.* This sector primarily utilizes durable plastics such as *PVC and HDPE* for pipes, interior fittings, and water tanks. However, recycling rates in construction remain alarmingly low, estimated at *less than 1%* in some regions, due to a lack of waste separation at the source and the prioritization of heavier materials like concrete and metal. By aligning with ambitious European goals, such as the *EU Green Deal's target to recycle 55% of plastic packaging by 2030,* this book explores how digital frontiers can be leveraged to *stop plastic waste from entering the natural environment* and secure a sustainable, circular future.

As can be seen, the scale of plastic waste is a significant global and regional challenge, driven by a dramatic increase in production and consumption coupled with historically low recycling and reuse rates. In the following there will be presented more fact and figures related to the plastic waste and pollution, including the micro/nanoplastic by considering the changes and challenges that population and organizations of all type should face.

1. Global and European production and consumption of plastic materials:
   - Exponential growth of plastic production that has surged from 1.5 million tonnes in 1950 to 359 million tonnes in 2018. This fact has supported and has been supported by the massive consumption increases, at the global scale, of plastics materials and parts that has increased twentyfold in the last 50 years (Ackerman & Levin, 2023).
   - In European Union countries, plastic consumption stands out as one of the highest globally, averaging 107 kg per capita annually. Approximately 40% of plastics materials are used for packaging, which is often characterized by a short lifespan and

single-use application. Together with packaging, the building and construction sector accounts for more than half of the total plastic consumption in Europe (Ackerman & Levin, 2023).

- In this context, and considering the current rates, plastic packaging volumes are expected to quadruple by 2050, reaching 318 million tonnes per year.

2. Low recycling and reuse rates of plastic parts, products or other type of waste are recorded in the actual period!
   - In Europe, only nearly one-third of plastic waste is recycled; globally, only about 14% of plastic packaging is even collected for recycling. Thus, practitioners and scientists agree that we are confronting with the recycling gap in the plastic materials! Despite the volume of waste, the demand for recycled plastics in Europe represented only 6% of the total plastic demand in 2018 and it seems that it is of low rate even in 2026. 'Across the European Union countries, people generate roughly 35 kilograms of plastic packaging waste per person each year, but only about 40–42% of that material is recycled. While this represents progress compared to a decade ago, improvement has been slow, and in many countries recycling rates remain well below EU targets. Only a small number of Member States are currently on track to meet the 55% plastic packaging recycling target set for 2030.'[4] Furthermore, the circular material use rate for plastics in the EU, the proportion of recycled material used in new products, was just 8.1% in 2020.
   - 'Recycling only works if manufacturers consistently use recycled plastic in new products. Without stable end-markets, collecting more plastic does not automatically lead to more recycling, and material that cannot be sold is often diverted to incineration instead. In that sense, the plastic recycling problem in 2026 is a systems issue. Without stronger demand for recycled plastics, simpler and more recyclable packaging design, and sufficient domestic processing capacity, higher targets alone are unlikely to deliver meaningful circularity.'[5]

[4] More details at https://www.wastepapertrade.com/blogposts/why-plastic-recycling-is-struggling-in-the-eu-in-2026

[5] See https://www.wastepapertrade.com/blogposts/why-plastic-recycling-is-struggling-in-the-eu-in-2026

- While construction industry is a major user of durable plastics (like PVC and HDPE pipes), its plastic recycling rate is estimated to be less than 1% in some regions, such as Malaysia (Chen et al., 2021; Tan et al., 2022). Even when plastic reaches recycling facilities, losses are high; the actual plastic recyclizes produced are often only about 65% of the total plastic waste that enters the facility.
- The most problematic sector in terms of low plastic waste management is the packaging one (Ncube et al., 2021). 'Plastics overall and packaging as its main application are priority materials within CE strategies, especially in EU policy. However, plastics have currently very low circularity, with less than 20% overall recycling in the EU and around 5% input of secondary streams to closed-loop applications. Moreover, while the understanding of potential environmental effects of large-scale transition to circularity for plastics has improved substantially, socioeconomic implications, and particularly the potential for environment-economy tradeoffs, are understudied' (Cimpan et al., 2023).

3. Economic loss and waste management aspect:
   - The current linear model (take-make-waste) is highly inefficient, with an estimated 95% of the material value of plastic packaging being lost to the economy after a single short use cycle. This lost value is worth approximately 105 billion annually which support the idea of value depletion (Szaky, 2019; Enthaler, 2026).
   - In Europe, 25% of all plastic waste still ends up in landfills. Furthermore, approximately 50% of the plastic collected for recycling in the European Union is exported to countries outside the Union due to a lack of local capacity or resources. Globally, 11% of all plastic waste went uncollected in 2016, and average collection rates in low-income countries remain below 50%. Thus, we assist to a great phenomenon of unmanaged waste (Ackerman & Levin, 2023; Enthaler, 2026).

4. Environmental and climate impact of plastic materials are hot subjects:
   - Over 99% of plastic is manufactured from fossil fuels, contributing significantly to greenhouse gas emissions. In 2019,

global plastic production and incineration released over 850 million tonnes of greenhouse gases into the atmosphere (Ackerman & Levin, 2023).

- The 'wear and tear' of products during use leads to massive unintentional releases of microplastics (pieces less than 5mm). Annual estimated releases in the European Union include:
  - Paints: 231,000 to 863,000 tonnes;
  - Tyres: 360,000 to 540,000 tonnes;
  - Pellets: 52,140 to 184,290 tonnes;
  - Textiles: 1,649 to 61,078 tonnes.

During and after the COVID-19 outbreak, an unprecedented requirement and consumption of plastic materials led to the release of single-use plastic products in the environment, and ever since pyramid of plastic waste in the environment has been burgeoning. It had been estimated that a massive amount of single-use plastic litter had been produced across the globe, with 1.6 million tonnes of PPE (facemasks) and 3.4 billion single-use facemasks being discarded daily during the COVID-19 period (Benson et al., 2021). The Asian continent produced the highest quantity of single-use plastic facemasks (1.8 billion per day), followed by Europe (445 million per day), Africa (411 million per day), Latin America (380 million per day), and North America (244 million/day). This pandemic has also led to an overall surplus increase in plastic pollution, which is also associated with negative impacts on biodiversity and reduced recycling provision. The published reports on global plastic pollution during the COVID-19 times showed short and long-term environmental risks associated with toxic GHG emissions from plastic production and incineration facilities. Due to this sudden boom of plastic pollution and lack of proper management of these plastic wastes, a new pandemic linked to the *plastisphere* may soon be affecting our environment and human health (Sharma et al., 2023).

In the same context, the pyramid of plastic waste in the environment has been burgeoning and there has been proposed and discussed the pyramid of plastic recycling (Figure 2.1) designed with reference to a series of scientific studies detailing the flow of recyclable plastics in Colombia, India, Indonesia, Kenya and South Africa. This general model varies with local recycling infrastructure and institutional context; ecology and sustainability practitioners and scientists support the fact that much plastic waste remains uncollected and unmanaged



FIGURE 2.1 The Pyramid of Plastic Recycling

NOTES Created using ChatGPT, based on Barford and Ahmad (2021).

(Barford & Ahmad, 2021). *The pyramid of plastic recycling* was proposed and designed with reference to a series of studies detailing the flow of recyclable plastics in Colombia, India, Indonesia, Kenya and South Africa. This general model varies with local recycling infrastructure and institutional context; ecology and sustainability practitioners and scientists support the fact that much plastic waste remains uncollected and unmanaged (Barford & Ahmad, 2021).

Furthermore, there is estimated that by 2050, the increased plastic production will be responsible for approximately 13 % of our planet's total carbon budget, equating to 615 coal-fired power station emissions (Hamilton & Feit, 2019; Sharma et al., 2023). In addition, the negative effect of plastic waste pollution has also been great expanded in the 'marine ecosystem, starting from shallow coastal areas to the deepest layers of the aquatic bodies sampled to date and in the most remote and sensitive locations on Earth (Napper & Thompson, 2020). Over the last two decades, marine pollution by plastic debris has been increasing and significantly contributing to global climate change. The impact of climate change is already in place in the form of a sea-level rise, ocean acidification, and extreme weather conditions, leading to socio-economic and ecological harm (Ford et al., 2022). Therefore, intensive

research on the impact of plastic pollution on climate change is the need of the hour so that decision-making agencies can frame mitigation policies to tackle this menace' (Sharma et al., 2023).

Rationale for the EDU4 PlastiCircular Project

In response to these challenges, the EDU4 PlastiCircular Erasmus+ Project was established under the title: Education for Plastic in a Circular and Climate Neutral Economy – Preventing Waste Ending Up into the Environment. This initiative seeks to foster a *climate-neutral economy* by bridging the gap between circular principles and practical educational tools. The project delivers three primary pillars of innovation:

1. *Gathering best practices* regarding the role of plastic in circular and neutral economies and provide a pedagogical base for education in the area;
2. Developing an interactive *e-learning classroom* to effectively disseminate specialized knowledge and to perform massive open online courses (MOOC);
3. Curating a *Digital Library of relevant materials* to provide a centralized hub for researchers and the public (promoting open science and lifelong learning initiatives).

To ensure inclusive education, the project's digital platforms incorporate *accessibility tools,* such as *high-contrast modes and readable fonts,* allowing a diverse range of beneficiaries to engage with the content. The success of this initiative is driven by an international consortium of six partners:

- Universitatea Politehnica Timişoara (Romania), https://www.upt.ro/ – project coordinator;
- Universitat Politecnica de Valencia (Spain), https://www.upv.es/index-en.html;
- Faculty of Environmental Protection Velenje (Slovenia), https://fvo.si/;
- Universitatea Transilvania din Brasov (Romania), https://www.unitbv.ro/;
- Universita degli Studi dell'Insubria (Italy), https://www.uninsubria.it/;



FIGURE 2.2 EDU4 PlastiCircular Consortium Members Logo

- Dermol svetovanje d.o.o. (Slovenia), https://dermol.si/.

EDU4 PlastiCircular is a unique and complex initiative developed by 6 partners from 4 countries supported by local and regional stakeholders committed to fill the existing gap in sustainable development education, management and work practices.

EDU4 PlastiCircular project is perfectly aligned to the European Council recommendation on learning for the green transition[6] and our initiative will provide learners of all ages (HEIS trainers/educators, students and also managers and employees of organizations) with training opportunities about the plastic in circular and climate neutral economy and sustainability (as a strong need!), thus making learning for the green transition a priority of HEIS via the green skills/competencies' development. Through EDU4 PlastiCircular initiative/training programme will enable behavioral changes for trainees/individual preferences, cultural values, awareness, responsible behavior and more generally support active engagement for EU climate neutral till 2050 (started from community, organization, region and country levels). Thus, the project incorporates many green practices/approaches as: green management, green mobilities, online/e-learning solutions, e-books, green pedagogy that will contribute to the green skills and competences development, green awareness, green careers/jobs (as supported by the project work packages content) and finally: green HEIS.

The main target group/target audiance of the course is *adult lifelong learners from EU countries* (aged 18–65), specifically:

- *Managers and employees* of different organizations (particularly

[6] See https://education.ec.europa.eu/news/learning-for-the-green-transition-and-sustainable-development

those who may collaborate with HEIS), who will apply the knowledge acquired from the course to make their organizations and processes greener regarding plastics.
- *HEI teachers/educators* (all categories of teaching staff), who will transfer the knowledge gained from the course to their students. HEIS teaching staff are main beneficiaries of the EDU4PlastiCircular open education resources but also trainers and consultants from business filed could be interested and attract in the training journey.
- *Students* from various engineering education programs, business administration and economics, including learners at different levels (BSC, MSC, PhD), who will be better prepared to manage, address and face future plastic/packaging challenges, plastic circularity strategies and plastic waste.

Digital tools play a fundamental role in ensuring and supporting the *sustainability of education* within the EDU4PlastiCircular project, offering long-term solutions for the dissemination of knowledge about the circular economy. They contribute to several keyways:

- *Accessibility and inclusion.* The project's digital platforms include essential *accessibility tools,* such as text enlargement, readable fonts, high-contrast modes, and light background options. These features ensure that educational resources remain accessible to a diverse range of users indefinitely.
- *Continuity of resources.* Through the creation of an *e-learning classroom* and a *Digital Library,* the project transforms information into a permanent resource. These tools allow beneficiaries to access study materials at any time, ensuring that the learning process continues well beyond the official completion of the project's activities.
- *Centralization of best practices.* Digital tools facilitate the gathering and organization of *best practices* regarding plastic in a circular and climate-neutral economy. This digital hub allows for rapid updates and information sharing among partners in *Romania, Slovenia, Spain, and Italy,* avoiding the ecological costs associated with physical transportation or printed materials.
- *Establishing long-term impact.* A central objective is to use these digital results to *establish the long-term sustainability* of the EDU4-

PlastiCircular initiative. The digital infrastructure serves as a foundation for future research and continuous public education aimed at preventing plastic waste from entering the environment.

In summary, digitalization transforms education from a one-time event into a continuous and scalable process, which is essential for the transition to a climate-neutral economy.

EDU4PlastiCircular Training and Certification Framework

Project Overview and Objectives

The EDU4PlastiCircular project represents a pioneering Erasmus+-funded initiative specifically designed to address education for responsible practices in plastic circularity and microplastics awareness within higher education. The project aims to foster green skills through comprehensive training on interconnected topics including the plastic world, waste management, circular economy, innovation, and responsible environmental behaviour. As an international collaboration involving multiple European partner institutions, EDU4PlastiCircular exemplifies the transnational approach increasingly recognized as essential for addressing global environmental challenges.

The project's core objectives centre on developing educational capacity to prevent plastic waste from entering the environment while promoting circular economy principles. This dual focus on prevention and circularity distinguishes EDU4PlastiCircular from initiatives that address only waste management or recycling in isolation. The project explicitly recognizes that achieving a circular and climate-neutral plastic economy requires fundamental changes in how plastics are designed, produced, used, and managed at end-of-life.



More innovative ideas on how to exploit the EDU4PlastiCircular created resources and more about the project could be found on the project web page https://microplastics.today

According to the project proposal, the EDU4PlastiCircular project, developed under the Erasmus+ Programme, contributes to one or more of the following programme's policy priorities:HORIZONTAL – Environment and fight against climate change. Additionally, there has been select one more priority: HE – Supporting digital and green capabilities



FIGURE 2.3 Project Home page, https://microplastics.today/

of the higher education sector. The project addresses these priorities (Figure 2.4) in the following ways:

1. The project contributes towards a better understanding of the circular economy of plastics via an extended training programme. It provides learners (HEIS teachers/trainers, students and managers from companies) a European overview of the Plastics World including production, conversion into parts and products, consumption, waste collection and treatment, including recycling (end-of-life aspects as production of recycled plastics and re-use in different application sectors). Awareness and responsibility of trainers and trainees are key behaviour effects of EDU4PlastiCircular training. Innovative aspect: EDU4PlastiCircular project results define green capabilities for HEIS education and for other organizations, too.
2. It includes the use of digital technologies for EDU4PlastiCircular training/education programme and management (cloud-based collaboration tools for communication, document, project, versions, meetings, risks, issues, change management). Innovative aspect: those well-established approaches/methodologies of plastic in the circular and climate neutral economy will be transferred and adapted to different educational domains of HEIS partners (teaching, managing, other remote work).
3. It includes innovative pedagogies for EDU4PlastiCircular education, awareness and behavioural adaptation using virtual learning and collaboration (e.g., cyberpedagogy, blended learning, micro-



FIGURE 2.4 The Three Main Domains Addressed by EDU4 PlastiCircular Project
NOTES Created using ChatGPT.

learning units, peer learning, gestalt-pedagogy based group sessions which include learning with artistic expression, body expression, psychodrama and emotion expression).

4. It addresses the differences in relation to the access to meaningful work based on geography – online/remote education/teaching offers trainers/HEIS educators an equal opportunity for teaching jobs without the need for relocation.

Pedagogical Approach and Methodology

EDU4 PlastiCircular employs innovative pedagogies including virtual learning, cyberpedagogy, and hybrid educational formats to maximize accessibility and engagement. This multi-modal approach reflects contemporary understanding that effective sustainability education must accommodate diverse learning preferences and contexts. A comprehensive gap analysis conducted within the project assessed both current knowledge levels and perceived usefulness of circular economy and plastics topics among students and academic staff, providing an evidence base for curriculum development.

Research findings from the project indicate that hybrid learning was

the overall preferred format, with students showing a slight preference for face-to-face instruction, while online learning was the least popular option. PowerPoint presentations were identified as the most preferred learning material, while printed and digital books received lower preference ratings. These insights have direct implications for designing educational programs that align with learner needs and preferences, potentially enhancing engagement and learning outcomes.

The project's methodology emphasizes competence-based learning, focusing on developing practical skills alongside theoretical knowledge. This approach aligns with broader trends in sustainability education toward action-oriented learning that prepares students to address real-world challenges. The integration of topics spanning from fundamental chemistry and materials science to policy and behavioural change reflects the inherently interdisciplinary nature of circular economy challenges.



More details regarding the pedagogical approach designed for training circular economy principles and plastic circularity aspects in the context of the EDU4 PlastiCircular project could be find in (Figure 2.5): https://microplastics.today/project-results/ The most useful material is the handbook for trainers with innovative methods and ideas for the educational process (Figure 2.6).

The pedagogical resources of the EDU4 PlastiCircular project are designed with a sophisticated modular approach that aligns with European competency frameworks. The project moves beyond simple 'awareness' to provide a structured educational journey tailored for higher education and professional development. The discussion below outlines the primary pedagogical pillars of the project:

1. *Competency-based framework (the skill card).* The backbone of the project's pedagogy is a visual *Skill Card* (a tree-shaped representation of competencies). It aligns the training program with:
   - *GreenComp,* the European sustainability competence framework, focusing on critical thinking and personal agency in environmental protection.
   - *EQF (European Qualifications Framework),* the resources are designed to fit different educational levels, ensuring that a BSC student and a corporate manager both receive content at an appropriate depth.
2. *Tiered learning paths.* Unlike 'one-size-fits-all' courses, EDU4 Plasti-

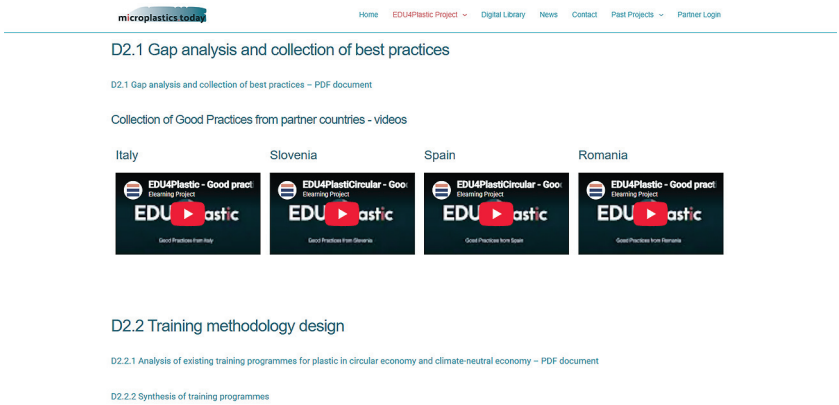


FIGURE 2.5 Access the D2.2 EDU4PlastiCircular Training Methodology Design



FIGURE 2.6 Handbook with Innovative Methods for Trainers

Circular utilizes *differentiated learning paths* (Level 1 to Level 3) to cater to three distinct target groups:

- *Students.* Focusing on technical knowledge and future-ready engineering skills.
- *Trainers/Educators.* Providing the methodological tools (the 'how-to') to transfer this knowledge to others.
- *Employees/Managers.* Emphasizing practical, implementation-ready solutions for making organizational processes 'greener.'

3. *Bloom's Taxonomy integration.* The curriculum is mapped using

Bloom's Taxonomy, ensuring a progression from basic knowledge and skills under the 'Remembering' level (understanding what microplastics are) to high-level skills 'Creating' (designing new circular economy solutions):

- *Foundation.* Terminology guides and 'About Plastics' readings.
- *Application.* Best practice case studies and cleaner production initiatives.
- *Evaluation.* Advanced sorting technologies and legislative compliance modules.

4. *Diverse teaching methods.* The instructional design is strongly aligned with modern sustainability framework, proposing a complex, modular learning environment, based on experiential, transformative, system-thinking paradigms:
   - *Dominant teaching & learning methods.* Expository methods (lectures and interactive lectures); Experiential learning (labs, simulations, workshops, internships); Inquiry-based learning (experiments, investigations); Problem-based learning (case studies, solution design) Project-based learning (prototyping, 3D printing); Gamification (quizzes, competitions); Reflective learning (diaries, vision maps, infographics, reflections); Collaborative learning (group work, role-play, debates).
   - *Competence orientation,* aligned with GreenComp framework. Systems thinking (e.g., plastic pathways, LCA); Critical thinking (evaluation of materials, policies); Action competence (solution design, sustainability audits); Self-awareness (reflection activities)
   - *Instructional architecture.* Each module is structured on topics comprising learning activities and assessment (LAAS) which integrate teaching methods for Lecture (knowledge input), Activity (active engagement); Assessment (feedback and validation), and Learning Resources.

5. *Diverse resource formats.* To accommodate different learning styles (visual, auditory, and kinesthetic), the pedagogical toolkit incorporates the following elements:
   - *Digital Library.* An open-access repository of e-books, multimedia presentations, and research papers.
   - *Interactive e-course.* Hosted on the Elearningproject.eu platform, featuring self-paced lessons and progress quizzes.

TABLE 2.1 Summary Table of Pedagogic Strategy

Feature	Pedagogic goal
Multilingual content	Inclusive access for diverse European populations.
Open Educational Resources (OER)	Promoting lifelong learning and accessibility.
Case study method	Bridge-building between theoretical knowledge and industry reality.
Continuous updates	Ensuring learners are informed by current scientific research (e.g., microplastics in the air/Antarctica).

- *Practical templates.* Worksheets that allow learners to audit plastic use in their own environments.

6. *Feedback and self-assessment.* A critical pedagogical feature is the *iterative assessment model.* The project uses a 'See What You Know' pre-assessment to baseline the learner's knowledge, followed by quizzes at the end of each module to validate progress. This allows for immediate reflection-a key principle of adult learning (*andragogy*).

By combining theoretical rigor with practical industry best practices, the EDU4 PlastiCircular project provides a robust ecosystem for anyone looking to transition from a 'linear' mindset to a 'circular' one.

Outcomes and Contributions

The EDU4 PlastiCircular project has generated valuable insights for designing educational programs aligned with the needs and preferences of students and academic staff in the circular economy and plastics domain. By conducting systematic gap analysis and preference assessment, the project provides an evidence-based foundation for curriculum development that can inform similar initiatives across different institutional contexts. The project's emphasis on green skills development addresses a critical need identified by the European Union and other policy bodies for workforce capacity in circular economy.

The project contributes to addressing the broader challenge of integrating sustainability into higher education curricula, which has been identified as essential for achieving Sustainable Development Goals. By focusing specifically on plastics and circular economy, EDU4 PlastiCircular provides a model for topic-specific sustainability education that

can complement broader environmental education initiatives. The project's international collaboration structure facilitates knowledge exchange and capacity building across European institutions, potentially accelerating adoption of circular economy education.

EDU4 PlastiCircular Digital Environment Development

The project Consotium has produced a range of deliverables, focusing on gap analysis, training methodology design, and open educational resources to define the training and certification programme. The most important EDU4 PlastiCircular project outcomes, defining *the created digital environment* that are visible and accessible for any learner are (Figure 2.7):

- Project webpage: https://microplastics.today/;
- Project deliverables, https://microplastics.today/project-results/;
- Digital library, https://microplastics.today/digital-library/;
- E-learning platform, https://elearningproject.eu/courses/edu4plasticircular-educating-for-sustainable-plastic-use-and-circular-economy/;

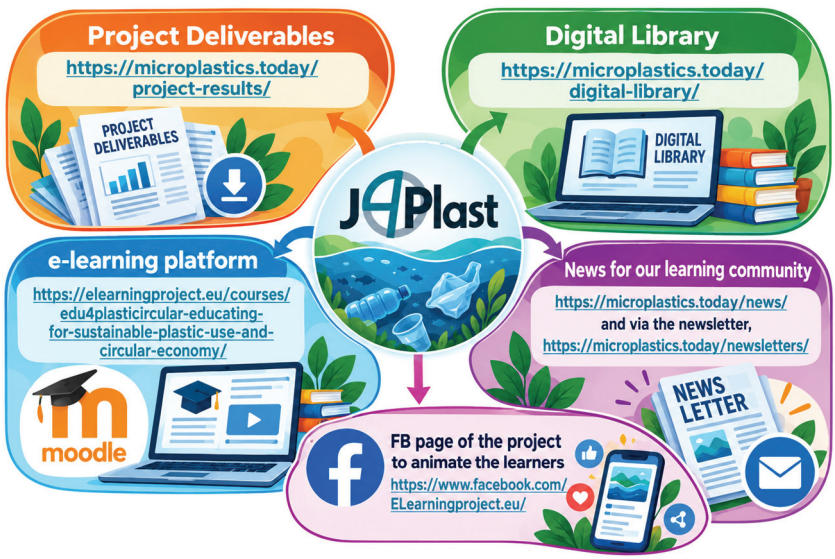


FIGURE 2.7 The Components of the EDU4 PlastiCircular Digital Environment (Created Using ChatGPT)

- News for our learning community: https://microplastics.today/news/ and via the newsletter, https://microplastics.today/newsletters/;
- FB page of the project to animate the learners https://www.facebook.com/Elearningproject.eu/.



Project web page, https://microplastics.today/

Microplastics.today is the official website for the EDU4PlastiCircular project, an Erasmus+ initiative funded by the European Commission. The site serves as an educational hub focused on the circular economy and the prevention of plastic waste and microplastics in the environment. Its primary features include:

- *Educational resources.* It hosts an E-course and a digital library containing materials related to plastic waste management and climate neutrality. This is the most populated area of the web dedicated to project deliverables, https://microplastics.today/project-results/ and the Digital Library, https://microplastics.today/digital-library/, too.
- *Project information.* It outlines the goals of the EDU4PlastiCircular project, which aims to provide education on preventing plastic pollution.
- *Collaborative network.* The site represents a partnership between several European institutions, including Universitatea Politehnica Timişoara (Romania), Universitat Politècnica de València (Spain), and the University of Insubria (Italy), among others.
- *Past initiatives.* It also maintains archives for previous related projects, such as the MicPlaPROB project.

The platform is available in multiple languages, including English, Italian, Romanian, Slovenian, and Spanish.

The library exhibits several key characteristics, outlined below:

1. *Content and formats.* The library contains a variety of educational and professional resources, including:

Digital Library, https://microplastics.today/digital-library/ is an open-access repository designed to support the EDU4 PlastiCircular project's mission of promoting a circular economy and sustainable plastic management.

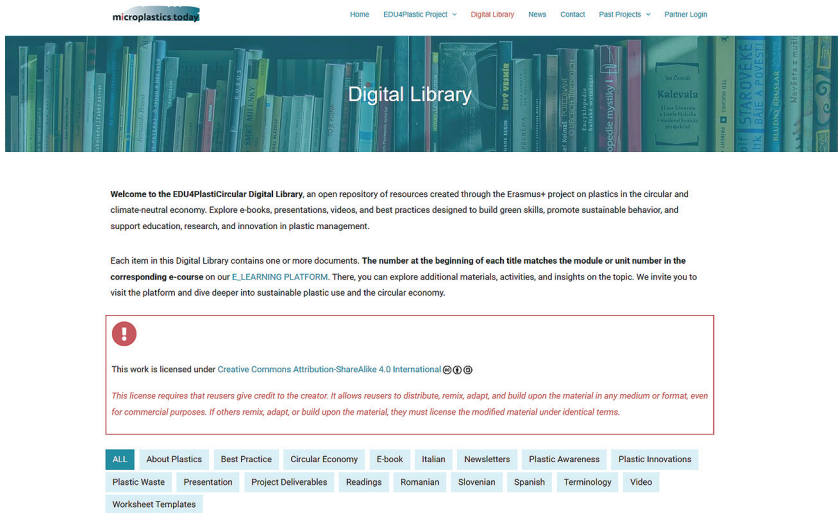


FIGURE 2.8 EDU4 PlastiCircular Digital Library

- *Presentations.* Visual slides covering specific modules.
- *Readings.* Detailed textual materials for deeper study.
- *Terminology guides.* Glossaries to help users understand technical language related to plastics and environmental science.
- *Worksheet templates.* Practical tools for educators and learners to apply the concepts.
- *Multimedia.* The repository also lists e-books, videos, and newsletters.

2. *Organizational structure.* The materials are organized to align directly with the project's *e-Learning Platform.* Each item is numbered (e.g., '1.1,' '1.2') to correspond with specific modules and units in the project's online courses.
   - Module 1.1: Focuses on plastics in daily life (uses, types, and impacts).
   - Module 1.2: Covers plastic materials typology and manufacturing technologies.

Subsequent modules explore recycling processes, environmental impacts, and circular economy strategies in greater depth.

3. *Multilingual support.* Reflecting the project's European partnership, the library provides translations for most documents. Resources are typically available in: English, Italian, Romanian, Slovenian, Spanish.
4. *Target topics.* Users can filter the library by various categories, such as:
   - *Circular economy.* Strategies for reducing waste and keeping materials in use.
   - *Plastic awareness.* Educating the public on environmental impacts.
   - *Best practices.* Real-world examples of successful plastic management.
   - *innovations.* New technologies and methods in the plastic industry.

The library is intended as a permanent resource for building 'green skills and competencies' among students, researchers, and professionals involved in environmental protection.



The e-learning platform, https://elearningproject.eu/courses/edu4plasticircular-educating-for-sustainable-plastic-use-and-circular-economy/

The created e-learning platform for implementing Massive Open Online Courses (MOOC) has been created (under the Moodle application) to host online courses and the Open Educational Resources (OERS) created and produced within the EDU4PlastiCircular Erasmus+ projects. All materials available on this platform are considered OERS, ready to be used and transferred into the higher education practices (for different courses, specialisations, programmes etc. and with different groups of students or learners). The e-learning platform is regularly updated by the EDU4PlastiCircular consortium members.

For most courses, registration is not required; however, *it is necessary to register* to participate in course forums, earn certificates of attendance, or receive Canvas Open Badges. The latter can be earned in some courses (Figure 2.9).

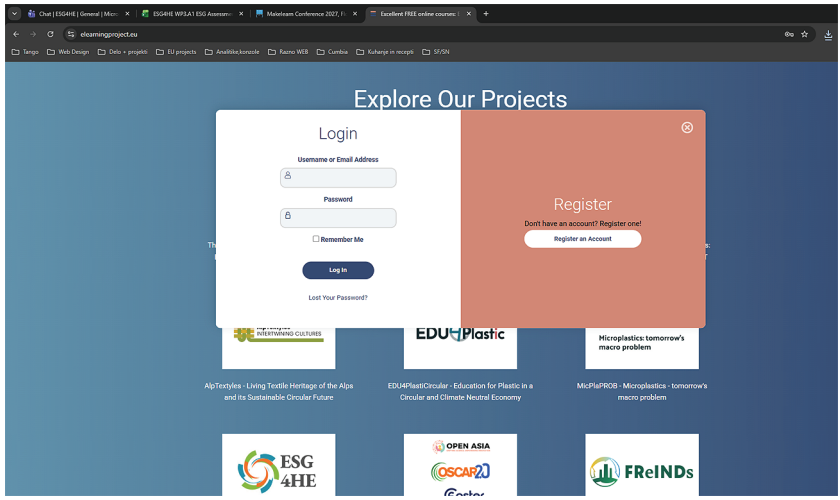


FIGURE 2.9 The Login and Register Page



BEFORE starting https://surveys.elearningproject.eu/microplastics-solving-expert/

AFTER completing the training and certification program, https://surveys.elearningproject.eu/microplastics-solving-expert/

FIGURE 2.10 'See What You Know' Survey to Gauge Knowledge Before and After the Course

Before starting the learning journey, it is recommended to check the actual knowledge of the potential learner and to offer a panorama of the knowledge considered in the EDU4PlastiCircular training program by having a preliminary assessment, using an online questionnaire. The same questionnaire is used after completion of the training to measure the degree of knowledge you achieve and to identify the areas of potential improvements.

The EDU4PlastiCircular e-course, titled 'Educating for Sustainable Plastic Use and Circular Economy.' This course is an Open Educational Resource (OER) developed under the Erasmus+ program to promote 'green skills' and responsible behaviour regarding plastic waste.



FIGURE 2.11 Description of the EDU4 PlastiCircular Training and Certification Programme per Modules

NOTES Structure of the E-Learning Platform and the Digital Library, created using ChatGPT.

1. *Core Modules.* The course is structured into five comprehensive modules, each containing several topics and quizzes (Figure 2.11 and Figure 2.12).
2. *Target audience.* The course is designed for adult lifelong learners (ages 18–65), specifically:
   - *Managers and employees.* To help green their organizational processes.
   - *HEI educators.* To transfer knowledge to students.
   - *Students (BSC, MSC, PhD).* Specifically, those in economics, management and engineering programs.
3. *Key features* of the e-learning platform are:
   - *Self-assessment.* Includes a 'See What You Know' survey to gauge knowledge before and after the course (Figure 2.10).
   - *Certification.* While registration isn't required to view materials, users must register to participate in forums and earn a Certificate of Attendance or Canvas Open Badges (Figure 2.13).
   - *Open Access.* All materials are provided under a Creative Commons license (BY-NC 4.0).



FIGURE 2.12 The Structure of the EDU4 PlastiCircular Training and Certification Programme

NOTES Created using ChatGPT.

- *Practical Tools.* Includes 'Smart Study Tips' and downloadable instructions for navigating the course and 'Instructions for Studying the Course' (Figure 2.13).

The overall goal is to shift the perspective of plastic from being seen merely as a pollutant to being treated as a valuable material that can be managed through smart, sustainable, and climate-neutral practices.

The News and Newsletter sections of the Microplastics.today platform serve as the primary communication channels for the EDU4 PlastiCircular learning community. They bridge the gap between academic research and everyday environmental awareness.



FIGURE 2.13 Procedure for the Recognition of Competencies upon Completion of an Online Course of EDU 4 PlastiCircular

News for our learning community:
Via the news page https://microplastics.today/news/

Via the newsletter, https://microplastics.today/newsletters/

1. *The News Section (Latest Updates).* The news feed provides real-time updates on project milestones, international outreach, and scientific insights (Figure 2.14). Key themes include:
   - *Global dissemination.* Recent articles highlight the project's expansion beyond Europe, such as presentations at the University of Eswatini and collaborations with the National University of Mongolia.
   - *Scientific awareness.* The feed features educational articles on 'hidden' plastic sources, such as microplastics in the kitchen or the discovery of plastic particles in remote areas like Antarctica.
   - *Academic collaboration.* It tracks meetings between partner universities (e.g., UPV in Spain, University of Insubria in Italy, and UPT in Romania) and Phd defenses that integrate project research.
   - *Communitye Events.* Reports on career fairs and youth aware-

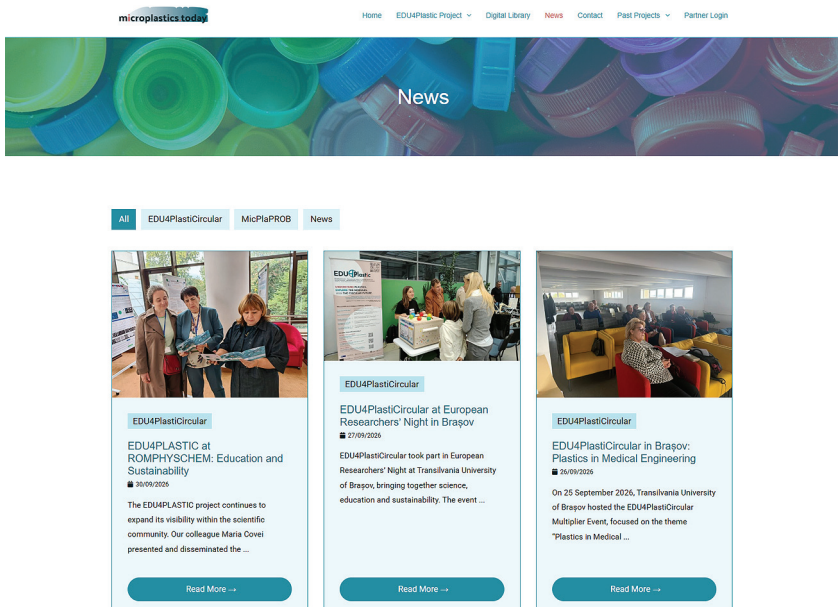


FIGURE 2.14 The News Section of the EDU4PlastiCircular Web Page (https://microplastics.today/news/)

ness programs (like 'Plastic Matters') where the project helps promote environmental careers.

2. *The newsletters (Project Milestones).* The newsletters serve as a formal record of the project's progress, typically released every few months (Figure 2.15). They are designed to:
   - *Synthesize results.* Each edition compiles the most important research findings and educational tools developed during that period.
   - *Announce resources.* They notify the community about new additions to the Digital Library, such as Spanish-language e-books or updated e-learning modules.
   - *Engage partners.* They spotlight the activities of specific partner institutions, ensuring that all stakeholders (students, teachers, and managers) are aligned with the project's circular economy goals.

Together, these channels ensure the learning community stays informed about the *lifecycle of plastic* – from the laboratory and class-

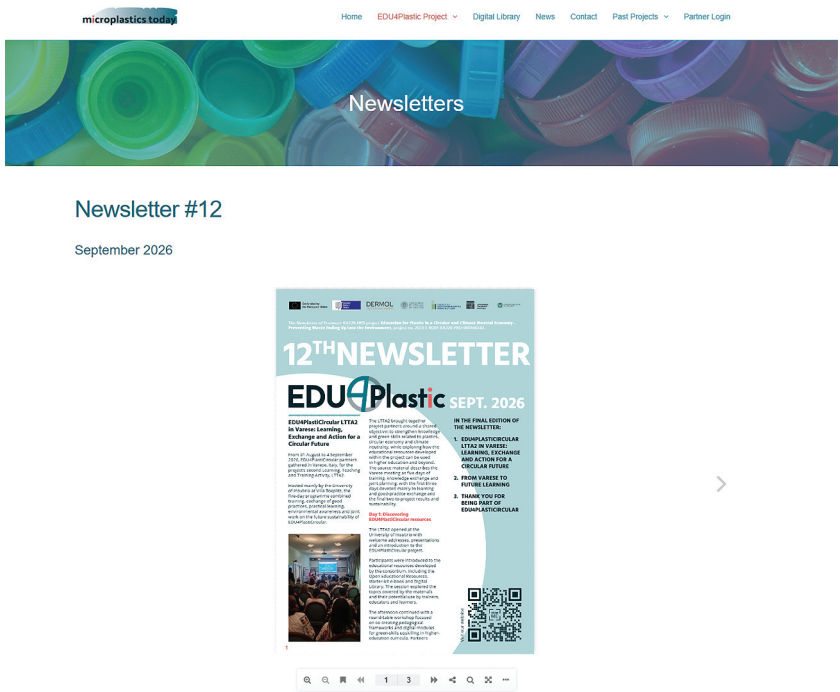


FIGURE 2.15 The Web Page of the EDU4PlastiCircular Newsletters (https://microplastics.today/newsletters/)

room to policy changes and individual consumer habits. For learners, following these updates is essential for staying current with the evolving standards and innovations in the circular economy.

FB page of the project to animate the learners
https://www.facebook.com/Elearningproject.eu/

The Facebook page for the Elearningproject.eu (which hosts the EDU4PlastiCircular project) acts as a dynamic social extension of the learning platform, specifically designed to *animate and engage learners* through interactive and visual content. Key features of the page that support the EDU4PlastiCircular community include (Figure 2.16):

1. *Interactive contests and student engagement.* The page is used to

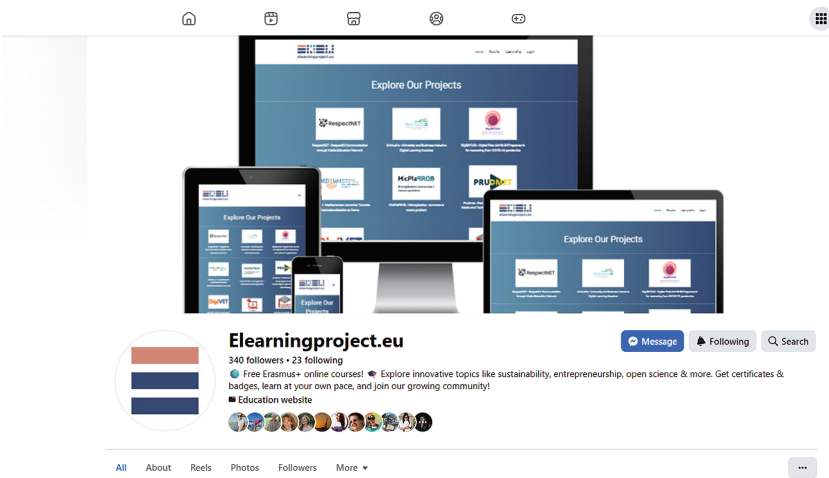


FIGURE 2.16 The Facebook Page That Hosts the EDU4 PlastiCircular Project Community

run awareness-raising activities that involve direct participation. A notable example is the 'Prevent Waste, Protect Our Planet' Facebook Contest, where students (such as those from the Transilvania University of Brasov, Romania) created social media announcements to educate the public about plastic pollution. This gamifies the learning process and encourages students to apply their 'green skills' in a real-world digital marketing context.

2. *Dissemination of results and news.* The page serves as a 'live' bulletin board for the project, sharing:
   - *Event highlights.* Photos and updates from international conferences (like MakeLearn or the Symposium on Circular Economy) and workshops where the project's results are presented.
   - *Newsletter alerts.* Announcements of new newsletter releases (e.g., the 8th edition), ensuring learners do not miss key project milestones.
   - *Collaboration news.* Updates on meetings between European partners, showing the international scale of the initiative.
3. *Educational 'bites' and awareness.* To keep learners motivated between formal modules, the page shares bite-sized insights, such as:
   - Facts about *microplastics in everyday environments* (like kitchens or remote regions).

- Tips for *sustainable habits,* such as waste-free meal preparation and plastic-free to-go meals.
- Discussions on *policy and legislation,* making complex topics more accessible through social media posts.

4. *Community building.* By following the page, learners become part of a larger European network. It facilitates:
   - *Networking.* Connecting students, HEI teachers, and managers across different countries (Italy, Slovenia, Romania, Spain, etc.).
   - *Open discussion.* Providing a space for feedback and debate on practical plastic waste management experiences.

In summary, while the e-learning platform provides the formal structure, the Facebook page provides the 'pulse' of the project, transforming educational content into a social dialogue that keeps learners motivated and connected to the environmental cause.

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