TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 67, IssueSpecial III, Jully, 2024

EDUCATION FOR PLASTIC IN A CIRCULAR AND CLIMATE NEUTRAL ECONOMY - PREVENTING WASTE ENDING UP INTO THE ENVIRONMENT

Anca DRAGHICI, Maria Elena BOATCA, Elena Cristina RADA, Dana PERNIU, Anja BUBIK, Cornelia BAERA, Roxana Mihaela SIRBU

Abstract: *Waste plastic materials create a huge pollution and being of great danger for our planet. Most of the accumulation of plastic parts of various sizes (such as parts of plastic parts, bottles, toys, bags, shoes, threads and fibers, clothes, etc.) comes from the process of consumption and use of plastic objects and it largely affects the Earth's environment, having negative effects on wildlife, wildlife habitat and human habitat alike. In this context, the paper is concerned with the designed of an awareness-prevention program via an original and comprehensive training program (available in multilingual for higher education institutions) aimed to reduce plastic waste and its impact in the early stages of the consumption. The presented initiative is supported by an Erasmus+ project which main objective is to develop and boost green skills of university teachers and students, managers and employees, green practices and awareness for plastic in circular economy and neutral economy and to contribute to the European Union's digital transformation by: (1) Creating innovative training methods and reference process framework based on best practices of education; (2) Releasing open training materials, e-learning platform and upskilling at least 200 learners; (3) Gathering best practices of plastic in circular and neutral economy, releasing starter pack. The paper is willing to demonstrate how an international consortium approach at the higher education level could impact education for sustainable development.*

Key words: *Education/training, plastic materials, waste, risk assessment, awareness.*

1. INTRODUCTION

Raising awareness about plastic pollution is crucial if communities want to overcome the challenges of plastic waste and the associated pollution phenomena [1], considering that plastic characteristics can change from country to country [2]. Documentaries presented by different broadcast televisions, on YouTube or on social media have brought the problem of plastic waste to the forefront. However, there is still much "space" for awareness and for changing attitudes and behaviors towards plastic, especially in our modern and very technological culture [3-5]. Furthermore, forecasts based on statistics data (Fig. 1) shows an increase in volume of the different type of waste till 2050. Assuming consistent use patterns and forecasting the current global waste management trends to 2050, 9000 Mt of plastic waste will be recycled, 12,000 Mt incinerated, and 12,000 Mt discarded in landfills or the natural environment [6]. In addition, different product lifetimes lead to a substantial change in industrial use of different plastics entering and leaving use each year (Fig. 2). Most plastic materials come from packaging; their end-of-life approach is appropriate to be based on circular economy principles.

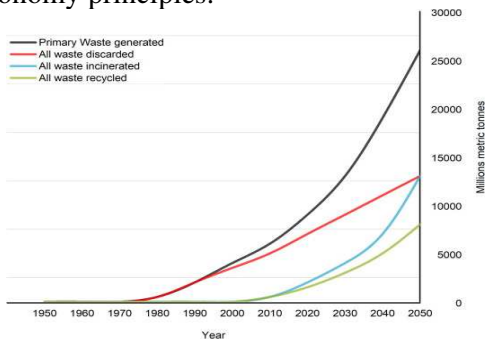

Fig. 1. Forecast of the cumulative plastic waste generation and disposal (in million metric tones) [6].

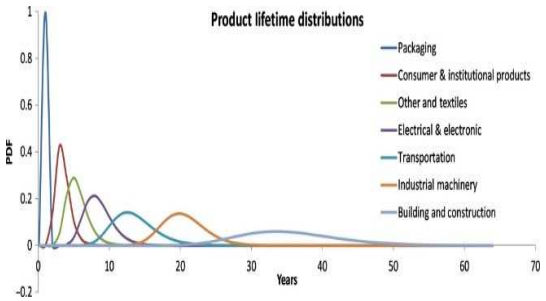

Fig. 2. Product lifetime distributions for the eight industrial use sectors plotted as log-normal probability distribution functions [5].

Plastic production has grown exponentially worldwide in the last two 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 [7,8]. 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 built under the circular and neutral economy principles (as supported by the Platform for Accelerating Circular Economy in their last annual reports https://pacecircular.org/news).

Furthermore, the research topics in the field of plastic waste are very diverse and cover most all the industries, product lifecycle phases or sustainability dimensions. Some of the most interesting are: recycling reuse; packaging industries; plastic waste construction material (cement brick, substitutes etc.); plastic waste mixed proportion; marine plastic waste and management stakeholder perceptions; public information campaign and trainings [9]; plastic waste sustainable development, water, rivers, marine plastic waste management; waste plastics coarse aggregate; waste plastics partial replacement, etc. Thus, production, use, and fate of polymer resins, synthetic fibers, and additives is still the concerned of industry, non-fiber plastics (henceforth defined as resins plus additives) and the largest groups of non-fiber plastics materials as PE, PP, and PVC, followed by PET, PUR, and PS are considered for the processes of implementing the circular economy [10].

In this dynamic and transformative environment of the plastic world a research question arises: "Can the level of awareness of the cycle of plastic products be increased in the case of future specialists with higher technical education and their adherence to a professional and social behavior attached to the circular economy and the consolidation of a climate neutral economy?" This question comes against the background of the observation that in the higher educations institutions (HEIs), faculties or universities, in the curricula of the different engineering specialization, there are very rare or even non-existent study subjects that produce this awareness and change the mind set regarding the design, production and use of plastic materials (representative studies and approaches are showing the power of education in promoting circular economy as [12-15]).

In this context, the paper is concerned with the designed of an awareness-prevention program via an original and comprehensive training program (available in multilingual for higher education institutions) aimed to reduce plastic waste and its impact in the early stages of the consumption. The presented initiative is supported by an Erasmus+ project which main objective is to develop and boost green skills of university teachers and students, managers and employees, green practices and awareness for plastic in circular economy and neutral economy. Furthermore, the paper is willing to demonstrate how an international consortium approach at the higher education level could impact education for sustainable development.

2. THE RESEARCH METHODOLOGY

First, the EDU4PlastiCircular initiative development and implementation has been designed based on the legal framework of Erasmus+ 2023 guidelines because of its adequacy of eligible activities finances. Thus, the requirements of the Erasmus+ key action 220, strategic partnership for HEIs was adopted. Second, the initiative has been built based on general project management principles.

The main steps of the adopted research methodology are:

1. Elaboration of the first draft of the initiative (general description) done by a group of experts from two Romanian universities. This has been followed of several consultations with local stakeholders of industry and circular

economy actors. Based on literature review and grey literature overview, university specialists have underlined the trends in plastic waste processes.

2. The international consortium building has been based on expertise needed for successfully implementing the EDU4PlastiCircular initiative. Considering some indicators of countries performance in recycling (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 the problem) Romanian universities have been filtered their international networks of past project partners. Thus, the international consortium has been established with HEIs from Romania, Italy, Spain and Slovenia and a small company from Slovenia.
3. Searching for opportunities partners have identified that the Slovenian partners have implemented (already finished) a small-scale Erasmus+ project entitled: "Microplastics - tomorrow's macro problem" and they agree to provide the opportunity of valorizing (extend to HEIs) the achieved knowledge and experiences, which has been considered adequate for reinforce the initiative.
4. Development of the Erasmus+ project proposal in a collaborative manner within the international consortium and detailed the activities, budget, time frame of implementation and key performance indicators (qualitative and quantitative).

This approach was not linear because of the cultural differences and diverse expertise of the partners; a lot of loops have been developed during the development of the initiative. Overall, the intensive discussions and creative actions during the online meetings for the initiative/project preparation were successful and the project proposal has been accepted for being financed.

In the following section will be given details of how the methodology was implemented.

3. THE RESEARCH APPROACH AND IMPLEMENTATION

3.1 Building the international consortium

An international consortium of specialists (Table 1) agreed to leverage their diverse but complementary expertise to define and implement the EDU4PlastiCircular initiative (entitled "Education for Plastic in a Circular and Climate Neutral Economy - Preventing Waste Ending Up into the Environment"). The competences, expertise and experiences of the teams and their members decided to be involved in supporting the initiative are of great importance and constitute the basis for success.

Table 1

EDU4PlastiCircular international consortium and their competencies and experiences.

Partner	Role	The knowledge base, experience and infrastructure provided
Politehnica University of Timisoara, Romania http://www.upt.ro/	Coordinator / UPT	(1) The knowledge base and experiences gained from LeadSUS project (Certified Leadership in Sustainability), LLP-LdV/TOI/2013/RO/022, http://leadsus.bicero.com/, 2013-2015; TeachSUS (Teaching and Educating for Sustainability), KA204, 2018-1-RO01-KA204-049253, https://www.teachsus.eu/, 2018-2020. (2) R&D laboratories and other developments of Research Center of Engineering and Management http://www.mpt.upt.ro/cercetare/proiecte.html are the EcoSec Lab and LeanSUS Lab - part of the Sustainable Development and Circular Economy Excellence Center. In addition, the Faculty of Industrial Chemistry and Environmental Engineering (http://www.chim.upt.ro) has the dedicated infrastructure and experts grouped in three research centers, most of them working and teaching different aspects of circular economy. (3) The Center of e-Learning facilitates availability of the training program on the UPT UniCampus (https://elearning.upt.ro/en/unicampus/) a MOOC supporting project implementation and sustainability.

		(4) Center of Competence in Plastics of UPT (established in 2014) with its network of stakeholder/investors which will be the beneficiary of the EDU4PlastiCircular training program, assuring the sustainability of the project by offering external services of training (VET) to people from companies
Dermol svetovanje d.o.o. Slovenia, https://dermol.si	Partner 1 (a company formerly leading Microplastic project) / DERMOL	(1) Dermol have built excellent relationships with approximately 10 schools during the execution of the Erasmus+ project "Microplastics - tomorrow's macro problem", https://microplastics.today/ (a small-scale Erasmus+ project). The project started in November 2021 and is ending in May 2023. (2) Dermol owns and manages several online learning portals, some in the English language, which were mostly created for various European (Erasmus+) projects in which the staff of Dermol participate either as individuals or as a company. The main portal in the English language, https://elearningproject.eu, hosts various online classrooms for more than 10 Erasmus+ projects. (3) Dermol has the experts for supporting the dissemination activities of the new initiative. (4) Dermol has built an excellent relationship with the Slovenian education system (pre-univ and HEIs), particularly with teachers of STEM subjects passionate about environmental education. They have provided them with resources and expertise to help teachers integrate this topic into their curriculum. "We believe that by working together, we can inspire the next generation to become environmental stewards and help protect our planet".
Fakulteta za varstvo okolja Slovenia Savinjska VELENJE http://www.vsvo.si/	Partner 2 (a faculty contributing to the implementation of the Microplastic project) / FVO	(1) The faculty has contributed to the successful implementation of the Erasmus+ project "Microplastics - tomorrow's macro problem", https://microplastics.today/ (a small-scale Erasmus+ project). The project started in November 2021 and is ending in May 2023. worked on raising awareness about the problem of microplastics among the student population in two countries: Slovenia and Italy. One of the main activities of this project was a video competition: students from both countries were invited to create short videos on the topic of "A World free of microplastics". The video competition was a huge success: students created 34 amazing videos showing they care deeply about the environment. Videos are available at the project website here: https://microplastics.today/competition/, and on the project's YouTube channel https://www.youtube.com/@microplasticstoday1680
Politecnica de Valencia, Spain, www.upv.es	Partner 3 / UPV	(1) The Materials Technology Institute (ITM) infrastructure and R&D staff offer a comprehensive R+D+I service in the business, industrial and construction sectors, to satisfy technological and research needs in the field of materials, processes and treatments. For this, ITM's main aim is to coordinate and expand the research offer of the research groups working in materials science and technology of the university, by optimizing the infrastructure and research teams, enhancing the multidisciplinary projects. The ITM for technological services to carry out an R+D+I project, has the following Laboratories: Microstructural characterization laboratories, Physical Characterization Laboratories – Mechanics Thermal characterization laboratories, Technological characterization laboratories, Laboratory of accelerated degradation of polymers, Metallographic samples preparation laboratory. (2) Experts working in the Group of Processing and Characterization of Plastic Materials (GPCMP) with which ITM began their journey. With the reformulation of the Research Groups, more in line with the new reality because of the evolution of the Groups, they became part of the Research Group on the Development of Materials for Sustainable Structures (DEMES), collaborating with other ITM Research Groups. (3) INNO3D+ project - 3D Printing Support Service for Innovative Citizens, https://www.inno3d.eu/ implemented in partnership with UPT and UTBV
Transilvania University of Brasov, Romania www.unitbv.ro	Partner 4 / UTBV	(1) The experience and educational resources, in digital format, as OERs developed through European projects: TOX-OER (www.toxoer.com), the PAES (http://paes.unical.it), and the BioEneryTrain (BET, H2020) projects (already ended), and through ongoing projects as EnvEdu OERs (http://envedu.unitbv.ro/en_US) and INES (http://ines.unibo.it).

		(2) R&D infrastructure and experts of the Environmental Engineering and Wastes Engineering study programs (master level). (3) The extended network of local a regional stakeholder in the filed of environment protection and the extended international network (due to their projects, conferences and internationalization strategy).
Universita Degli Studi dell'Insubria, Italy www.uninsubria.it	Partner 5 / DiSTA	The R&D resources and infrastructure from: (1) The Dipartimento di Scienza e Alta Tecnologia (DiSAT) pursues the goal of harmonizing basic research with applied research, basing its raison d'être on a unified vision of scientific and technological research. The Department was created around the idea of combining hard sciences, or STEM (Science, Technology, Engineering, Mathematics) in a single research environment, without neglecting contributions from other disciplines, with the idea of promoting interdisciplinary research and to train students with a global scientific vision. Furthermore, this choice allowed them to be able to count on the advantages of scale, usually possible only in large universities, without losing the agility of a small structure. The research areas are represented by four Sections: Environment-Health-Safety-Territory, Chemistry, Physics, Mathematics. (2) The research expertise of the DiSTA is developed around three sections: environment, computer science and humanities. In the current context of globalization and internationalization, among the most innovative and peculiar aspects of the research activity of the Department - in parallel with the advancement of each single subject area - there are consequently the richness of the research topics of the teachers and the tendency to create virtuous multidisciplinary paths also open to numerous and fruitful national and international collaborations, often integrated with teaching activities. (3) Dipartimento di Biotecnologia e Scienze della Vita – DBSV concerns the well-being of humans, animals, and the environment. In particular, the Biological Sciences and Technologies Section promotes innovative strategies in the most advanced sectors of industrial, biomedical, diagnostic, animal, plant, microbial, cellular and molecular biology and biotechnology also aimed at the production of goods and services, while the Medical and Surgical Sciences Section carries out clinical and research activities with the aim of improving the patient's well-being. (4) Experts in environmental engineering and labor environment sustainability, environment issues and labor security engineering, biotechnology, environmental impact, and accident and risk analysis.

3.2 The initiative objectives

The project addresses the Erasmus+ horizontal priority "Environment and fight against climate change" and "Supporting digital and green capabilities of the higher education sector" in the following ways (based on the partners' research expertise and experience in training programs design and implementation):

1. The project contributes towards a better understanding of the circular economy of plastics via an extended training programs. 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 behavior effects of EDU4PlastiCircular training. Innovative aspects considered are related to the fact that 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 program and management (cloud-based collaboration tools for communication, document, project, versions, meetings, risks, issues, change management). Innovative aspect considered are related to those well-established approaches and 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 behavioral adaptation using virtual learning and collaboration (e.g., cyberpedagogy, blended learning, micro-learning units, peer learning, gestalt-pedagogy based group sessions which include learning with artistic expression, body expression, psychodrama and emotion expression). These will contribute better to the awareness about the plastic waste and impact in the case of students (of engineering studies and other specializations), teachers, trainers, managers, employees and other people that will be informed by the project partners about the initiative.

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.

Furthermore, the project addresses and evolves in three key areas: environment and climate change, green skills and digital content and pedagogical practices. EDU4PlastiCircular is a unique and complex initiative developed by six partners from four countries supported by local/regional stakeholders committed to fill the existing gap in the sustainable development education, management and work practices. EDU4PlastiCircular project is perfectly aligned to the European Council recommendation on learning for the green transition and the 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, thus making learning for the green transition a priority of HEIs via the green skills and competencies' development. Through EDU4PlastiCircular initiative (and the associated training program) 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).

Furthermore, the initiative incorporates many green practices and approaches as: green management, green mobilities, online/e-learning solutions, e-books, green pedagogy that will contribute to the green skills/competences development, green awareness, green careers/jobs and green HEIs.

The project has two joint objectives: O1. Education for sustainable development in general and education for plastic in circular economy and neutral economy, in particular; O2. Development of digital competences in the context of the training/education program. The purpose is to develop and boost green skills of HEIs teachers and students, managers and employees, and green practices for plastic in circular economy and neutral economy. Also, it contributes to the EU's digital transformation.

The specific objectives are:

SO1: To gather best practices of plastic in circular economy & neutral economy and prepare reference process models (policies and rules). Results: Handbook with best practices, curriculum, syllabus, skills card definition.

SO2: To design innovative training methods tailored for HEIs staff and students, managers and employees. Results: Handbook with innovative training methods.

SO3: To implement training materials and deploy them using online and mobile classrooms. Results: digital library with training materials, e-learning content, e-learning platform.

SO4: To test and verify the efficiency of the learning methods, materials and innovative online/mobile learning platform. Results: tested e-learning platform, performed online and live courses, 200 educated pilot learners.

SO5: To ensure sustainability, usefulness and longevity of the EDU4PlastiCircular training program and other project deliverables. Results: sustainability plan and business model for after-project ends, signed agreement with partners future collaborations with five concrete actions, signed letters of cooperation with (future) remote work companies and/or public bodies.

3.3 Innovative aspects and added value

EDU4PlastiCircular initiative was designed as a creative combination of green skills, social responsibility and green ethics behaviors, and digital skills. The aim is to respond to a stringent need for improved education methodologies to

introduce circular and climate neutral economy topics, waste management, developing life cycle thinking related to product/process design. Our e-learning content will improve the effectiveness, interactivity of online teaching in engineering and reduce dropout rates of online education.

In addition, the project generates an effective method for knowledge and skills transfer related to sustainability and circular economy topics to change mindsets and induce sustainable and responsible behavior in both HEIs and companies. Despite that, there are various courses on plastic management, to our knowledge there is no training course to be delivered as e-learning content that will address such a high variety of topics related to plastic in circular and neutral economy; the innovative character of the EDU4PlastiCircular training program resides in the comprehensive target groups belonging to HEIs (both teachers and students) and other organizations (managers and employees).

The next aspect of innovativeness is the format of training which will be prepared. The training will include web- and online learning, micro-learning, social media-based learning, meme-based learning, peer learning mechanisms included. This will help to prevent dropouts from the training program and increase the motivation of the learners to finish the course and get the certification.

The added value of the initiative (as an Erasmus+ project) at EU-level is the following:

1. Multi-country target groups and the feedback - The feedback of participants from different countries will allow quality checking of the course from different perspectives. Based on the feedback from international participants, the training materials, the awareness actions will be better adapted for usage in the whole EU.

2. Knowledge and best practices transfer between multiple countries and fields - The consortium partners belong to four different countries, have expertise in various fields and provide educational services in different domains. Therefore, their educational needs are met differently, depending on the particularities and educational demand from each country. The project is aimed at addressing a multicultural, diverse target group that includes all EU countries and learners from both HEIs and companies (in the final, after-end project stage).

3. Multi-language and dissemination - The project's results and dissemination will be available in multiple languages (EN, RO, SI, IT, ES), which will allow its absorption in different countries. Implications of plastic use on the circular economy and neutral economy are a global issue that requires tackling from a variety of perspectives, including adherence to Sustainable Development Goals (SDGs). This makes the topic of the project a priority EU-level matter.

3.4 Initiative implementation activities

Considering each partner's experience and competencies, the tasks and responsibilities were assigned correspondingly. In the proposal phase of the initiative, tasks were distributed among partners. Detailed planning will follow in the first month of the project implementation. Project management principles were applied and a series of work packages (WP) were defined. First, each partner has been decided to be responsible for the implementation of all WP or deliverable. Further, along with the active development role of a WP, the partners will actively be involved in development and implementation of other WPs with different roles (co-developer, quality reviewer, tester, evaluator etc.). The major benefit of this sort of task distribution is a good content dissemination inside the consortium, which serves as the basis for dissemination outside the consortium.

The WP of the project through the initiative will be applied are described in the following.

WP1 (Project management) will be led by UPT due to their competencies in project management proven in other EU projects and strong expertise in sustainability, circular economy and plastics.

WP2 (EDU4PlastiCircular training methodology design) will be led by UPV considering their expertise in the development of courses, pedagogical methods and learning content. UPV will be strongly supported by UPT in leading this WP.

WP3 (EDU4PlastiCircular digital content design) will be led by DiSTA and FVO on

account of their experiences with the development of training materials.

WP4 (EDU4PlastiCircular implementation and exploitation) will be led by UTBV considering their experiences in implementing different learning/education programs, previous projects implementation and performance management. DERMOL and DiSTA will accompanying the leading task of this WP.

WP5 (EDU4PlastiCircular dissemination and sustainability) exploitation will be managed by DERMOL due to their long experience and creativity in dissemination activities in various networks and strong capabilities in transferring courses into academic curriculum. Also, dissemination activities (Web and social media activities, graphical design) will be led by DERMOL.

Project meetings and Multiplier Events will be managed by partners of the meetings' target countries (Romania, Slovenia, Italy and Spain). Project administration and management will be led by UPT. Technical management (preparation of deliverable specifications) will be led by DERMOL.

The consortium contract (signed at the start of the project) will formalize all partners' responsibilities. Each partner will assign a local project lead, who will ensure the good performance of the partner's team. Tasks and responsibilities will be tracked by each partner project manager (e.g., using a created virtual space on Google Drive) and will be analyzed during the monthly online project meeting.

4. CONCLUSIONS

In conclusion, some general considerations must be made about the presented initiative:

- The presented initiative is related to an extremely current and serious problem, at least at the level of Romania (also confirmed by recent studies as [16, 17]).
- The adopted methodology is complex and based not only on requests for specialized literature, but also consultation actions with representative stakeholders of the field of waste management, from the field of engineering education, as well as with direct beneficiaries.
- In addition to the aspects presented regarding the method of implementing the initiative, the following were established: the mode of communication and collaboration between partners, the description and management of the WP activities, the Gantt chart for the implementation of the WP and the budget allocated to them. They were not presented for reasons of confidentiality.
- In addition to those shown in this article, each partner will build a local, regional network of collaborators, facilitating actors of the initiative so that the expected (desired) impact is ensured.

EDU4PlastiCircular key performance indicators (KPIs) related to each WP were that described in detail the project proposal as qualitative and quantitative indicators together with methods for monitoring and control. EDU4PlastiCircular consortium will assess if the project objectives were achieved by: (1) defining qualitative and quantitative indicators and (2) by monitoring during the whole project if these indicators were achieved. A separate Quality management plan and Dissemination plan will be developed at the beginning of the project with details about indicators, thresholds, timing, responsible partners.

Quantitative indicators: are defined for each deliverable, multiplier events that will be organized and transnational project meetings: number of live events participants, number of learning modules, number of pages or chars/learning module, number of e-learning participants/enrolled, number of issued digital badges/certificates, number of reached people during dissemination actions, number of web page/social media viewers, time spent for completing the course etc. Qualitative indicators refer to the quality of the content/materials will be ensured by collecting feedback from course attendees (HEIs educators, students, managers and employees). Comments (feedback) from trainees will be analyzed and results will be considered for the training materials improvement. The quality of the learning materials will be improved based on the responses of external trainees. A questionnaire for the evaluation of the quality of training

materials will be created and responses will be gathered (survey report). Satisfaction with the course content, usability for education/learning/work life, ease of use will be measured. Expert peer-review feedback will be collected, too. The training materials will be reviewed and evaluated by field experts.

5. ACKNOWLEDGEMENT

The paper is related to the development of the EDU4PlastiCircular project: "Education for Plastic in a Circular and Climate Neutral Economy - Preventing Waste Ending Up into the Environment" (Erasmus+ 2023-1-RO01-KA220-HED-000166242), founded with support of the European Commission. This paper and the communication reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The presented research was supported by project POCU 153770, entitled "Accessibility of advanced research for sustainable economic development – ACADEMIKA", co-financed by the European Social Fund under the Human Capital Operational Program 2014-2020.

6. REFERENCES

[1] Plastic Pollution, https://en.wikipedia.org/wiki/ Plastic_pollution

[2] Rada E.C.,Ionescu G., Ferronato N., Ragazzi M., Raspanti M., Fabio C., Torretta V., *Zooming on light packaging waste differences by scanning electron microscopy,* Environmental Science and Pollution Research 28, 42, 59076 – 59082, 2021

[3] Lebreton, L., & Andrady, A., *Future scenarios of global plastic waste generation and disposal.* Palgrave Communications, 5(1), 1-11, 2019.

[4] Meijer, L. J., Van Emmerik, T., Van Der Ent, R., Schmidt, C., & Lebreton, L., *More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean.* Science Advances, 7(18), eaaz5803, 2021.

[5] Zulkernain, N. H., Gani, P., Chuan, N. C., & Uvarajan, T., *Utilisation of plastic waste as aggregate in construction materials: A review*. Construction and Building Materials, 296, 123669., 2021.

[6] Geyer, R., Jambeck, J. R., & Law, K. L., *Production, use, and fate of all plastics ever made*. Science advances, 3(7), e1700782, 2017.

[7] Ragazzi M., Rada E.C., Schiavon M., *Municipal solid waste management during the SARS-COV-2 outbreak and lockdown ease: Lessons from Italy*, Science of the Total Environment, 745, 141159, 2020.

[8] Rai P.K., Sonne C., Song H., Kim K.H., *Plastic wastes in the time of COVID-19: Their environmental hazards and implications for sustainable energy resilience and circular bio-economies,* Science of the Total Environment, 858, 159880, 2023.

[9] City of Westmister, *Plastic waste – everything you need to know,* https://cleanstreets.westminster.gov.uk/plastic-waste-complete-guide/#1

[10] Khalid, M. Y., Arif, Z. U., Ahmed, W., & Arshad, H., R*ecent trends in recycling and reusing techniques of different plastic polymers and their composite materials*. Sustainable Materials and Technologies, 31, e00382, 2022.

[12] Serrano-Bedia, A. M., & Perez-Perez, M., *Transition towards a circular economy: A review of the role of higher education as a key supporting stakeholder in Web of Science.* Sustainable Production and Consumption, 31, 82-96, 2022.

[13] Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., ... & Vara Prasad, P. V., *Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions.* Sustainability, 13(17), 9963, 2021.

[14] Bugallo-Rodríguez, A., & Vega-Marcote, P., *Circular economy, sustainability and teacher training in a higher education institution.* International Journal of Sustainability in Higher Education, 21(7), 1351-1366, 2020.

[15] Wandl, A., Balz, V., Qu, L., Furlan, C., Arciniegas, G., & Hackauf, U., *The circular economy concept in design education: Enhancing understanding and innovation by*

means of situated learning. Urban Planning, 4(3), 63-75, 2019.
[16] Boca, G.D., & Saraçli, S., *Effects of Romanian Student's Awareness and Needs Regarding Plastic Waste Management*. Sustainability, 15(8), 6811, 2022.
[17] Soare, B.E., & Tarhini, M., *The Evolution of the Total Waste Generated and Recycled in Romania*. The 5th International Conference on Economics and Social Sciences Fostering recovery through metaverse business modelling June 16-17, 2022 Bucharest University of Economic Studies, Romania, 148, 2022.

Educația în domeniul materialelor plastice în economie circulară și neutră climatic Prevenirea deșeurilor în mediu

Deșeurile din materiale plastice creează o poluare uriașă, reprezentând un mare pericol pentru planeta noastră. Cea mai mare parte a acumulării de piese din plastic de diferite dimensiuni (precum obiecte din plastic, recipiente, jucării, pungi, cutii, pantofi, fire și fibre, haine etc.) provine din procesul de consum și utilizare a produselor din plastic și afectează în mare măsură mediul Planetei, având efecte negative asupra habitatului vieții sălbatice și asupra habitatului uman deopotrivă. În acest context, lucrarea se referă la conceperea unui program de conștientizare-prevenire printr-un program de instruire original și cuprinzător (disponibil în multilingv pentru instituțiile de învățământ superior) menit să reducă deșeurile de plastic și impactul acestora în fazele incipiente ale consumului. Inițiativa prezentată este susținută de un proiect Erasmus+ care are ca obiectiv principal dezvoltarea și stimularea competențelor ecologice ale profesorilor și studenților universitari, managerilor și angajaților, practicilor ecologice și conștientizarea pentru plastic în economia circulară și economia neutră climatic și să contribuie la transformarea digitală a Uniunii Europene. prin: (1) Crearea unor metode inovatoare de formare și a unui cadru de referință al procesului bazat pe cele mai bune practici din educație; (2) Dezvoltarea de materiale educative deschise, a unei platforme de e-learning și perfecționarea a cel puțin 200 de cursanți; (3) Colectarea celor mai bune practici pentru materialele plastice în economia circulară și neutră climatic cu lansarea unui pachetului de inițiere a proiectului. Lucrarea demonstrează modul în care o abordare internațională într-un consorțiu de de parteneri în majoritate de la nivelul învățământului superior ar putea avea un impact asupra educației pentru dezvoltare sustenabilă.

Anca DRAGHICI, Prof. Dr. Eng., Politehnica University of Timisoara, Faculty of Management in Production and Transportation, anca.draghici@upt.ro, +40 256-404284, 14 Remus Str., 300191 Timisoara, Romania.
Maria Elena BOATCA, As. PhD, Politehnica University of Timisoara, Faculty of Management in Production and Transportation, maria.boatca@upt.ro, +40 256-404284, 14 Remus Str., 300191 Timisoara, Romania.
Elena Cristina RADA, Prof. q. Dr., Insubria University, Theoretical and Applied Science Dep. - DiSTA, elena.rada@uninsubria.it; +39 0332 218782; Via G.B. Vico, 46 – Varese, Italy, I – 21100
Dana Perniu, Prof. Dr., Transilvania University of Braşov, Mechatronics and Environment Department, Mechatronics and Environment Department, d.perniu@unitbv.ro, 29 Eroilor Blv., Brasov, Romania
Anja BUBIK, Assoc. Prof. Dr. Faculty of Environmental Protection, anja.bubik@fvo.si, Velenje, Slovenia
Roxana Mihalea SIRBU, PhD, Assistent, Politehnica University of Timisoara, roxana.sirbu@upt.ro, +40 256-404284, 2 Victoriei sqr. 300006 Timisoara, Romania and post-doc researcher at "1 Decembrie 1918" University, Alba Iulia, Romania
Cornelia BAERA, PhD, Lecturer, Politehnica University of Timisoara, Faculty of Management in Production and Transportation, cornelia.baera@upt.ro, +40 256-404284, 14 Remus Str., 300191 Timisoara, Romania.