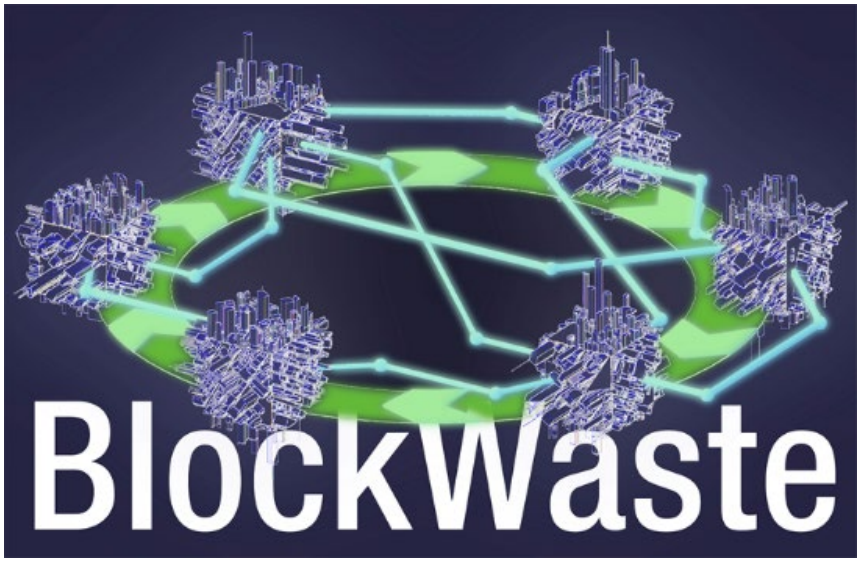
O2.A2 Production of a municipal waste management curriculum using blockchain technology



Disclaimer

This project has been funded with support from the European Commission. This publication reflects 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.

ΙΔΡΥΜΑ ΚΡΑΤΙΚΩΝ ΥΠΟΤΡΟΦΙΩΝ IKY

Co-funded by the Erasmus+ Programme of the European Union

Output factsheet:

Funding Programme	Erasmus+ Programme of the European Union
Funding NA	EL01 Greek State Scholarship's Foundation (IKY)
Project full title	Innovative training based on Blockchain technology applied to waste management - BLOCKWASTE
Field	KA2 - Cooperation for innovation and the exchange of good practices KA203 - Strategic Partnerships for higher education
Project Number	2020-1-EL01-KA203-079154
Project Duration	24 months
Project Start Date	01-10-2020
Project End Date:	30-09-2022

Output details:

Output title: O2: European common curricular on MSW applying Blockchain technologies for Circular Economy strategies

Task Title: A2 - Production of a municipal waste management curriculum using blockchain technology

Output leader: Bielefeld

Task leader: Bielefeld

Author(s): Bernd Kleinheyer, Bielefeld UAS, bernd.kleinheyer@fh-bielefeld.de, Germany, Rainer Lenz, rlenz@fh-bielefeld.de, Bielefeld UAS, Germany, David Caparros Perez, Centro Tecnológico del Mármol, Piedra y Materiales, david.caparros@ctmarmol.es, Spain Paraskevas Tsangaratos, National Technical University of Athens, ptsag@metal.ntua.gr, Greece, Christa Barkel, Saxion UAS, c.barkel@saxion.nl, Netherlands

Reviewed by: Maria Menegaki, National Technical University of Athens, menegaki@metal.ntua.gr, Greece, Perry Smit, Saxion UAS, p.j.smit.01@saxion.nl, Netherlands

Document Control

Document version	Version	Amendment
V0.1	29/10/2021	Final Version – 28/12/2021

Contents

List of abbreviations

Abbreviation	Definition
MSW	Municipal solid waste
MSWM	Municipal solid waste management
MWM	Municipal waste management
CE	Circular Economy
SMEs	Small and medium enterprises
IT	Information technology

Executive summary

This curriculum suggests topics and materials that complement teaching and learning offers for Waste Management typically found on established Engineering degrees (Civil Engineering, Environmental Technologies) but also Environmental Technologies or Sustainable Business Management. The curriculum addresses the need for skills that help transform mostly 'linear' Waste Management into Circular Economy processes and shift the perception of 'waste' to 'resource'. On the technical and technological side, the curriculum features on innovative tools and processes that help municipal and private waste management organizations deal with new economic challenges like climate change mitigation, resource efficiency and environmental damages.

Particular attention is given to data mining and data circulation, both functions that contribute massively to reaping the benefits of digitalization for climate- and environmentally friendly business practices. The instrumental focal point in this are Blockchain and Distributed Ledger technologies that are seen as facilitating both industrial processes in the Circular Economy and higher levels of transparency to stakeholders.

Co-funded by the Erasmus+ Programme of the European Union

1 Introduction

1.1 Brief project description

The BlockWASTE project aims to address the interoperability between waste management and blockchain technology and promote its proper treatment through educational training, so that the data collected will be shared within a safe environment, where there is no room for uncertainty and mistrust between all parties involved. For this purpose, the objectives of BlockWASTE project are as follows:

- To conduct research on solid waste generated in cities and how it is managed, so that it can be used to create an information base of good practices, in order to reintroduce waste into the value chain, promoting the idea of Intelligent Circular Cities.
- To identify the benefits of the Blockchain Technology within the municipal waste management (MSW) process.
- To create a study plan that allows the training of teachers and professionals of organizations and companies of the sector, in the overlap of the fields of Waste Management, Circular Economy and Blockchain Technology.
- To develop an interactive tool based on Blockchain Technology, which will make it possible to put into practice the management of data obtained from urban waste, thus visualizing the way in which the data is implemented in the Blockchain and enabling users to evaluate different forms of management

BlockWASTE aims to implement transnationally new educational contents with the goal of training its students in the partner countries and providing them with the necessary basic skills that allow them to act professionally as future workers in the sector, adding digital competences required by companies that are embracing the process of digital transformation. In this sense, the project is addressed to:

- Enterprises and SMEs, IT professionals, urbanisms and waste management professionals.
- Universities (professors, students and researchers).
- Public bodies

The project includes four Intellectual Outputs as follows:

- O1. Learning materials for interdisciplinary Blockchain-MSW
- O2. European common curriculum on MSW applying Blockchain technologies to Circular Economy strategies
- O3. E-Learning tool based-on Blockchain-MSW focused on Circular Economy
- O4. BlockWASTE Open Educational Resource (OER)

1.2 Commentary

The challenges in Waste Management is currently going through due to climate change, global warming, the waste production and disposal crisis and digitalization have triggered efforts at political, industry, scientific and also educational levels (Directive 2018/851). Investment is made in equipment, facilities and industrial processes, public administrations and also research and education.

The changes that the climate crisis and other factors trigger have a dramatic impact not only on the content of learning but also on learning modes and environments. Digital learning options, changes in organizations, disappearance of hierarchies and similar factors have created a demand for self-management, lifelong and just-in-time learning (Laloux, 2014). At the same time, cross-disciplinary 'transgression' and a generally constant turnover of learning content have made open and adaptable curricula imperative. The acceleration in the emergence of digital options such as Machine Learning or Blockchain available for waste management (Bozkurt & Stowell, 2016) has shaken up educational agendas across the globe in a way that curriculum designers, whatever the discipline, risk lagging behind developments in the real world, especially in Academia where adjustment processes are often slow and 'silo' mentalities cemented.

The Blockwaste project set out to make a contribution to educational resources supporting the changes and skills building required to establish a circular economy and to transform the concept of 'waste' into one of 'resource'. The Blockwaste study of existing curricula in a number of EU countries (see for details: BlockWASTE deliverable "O2/A1.1 Comparative study of the curricula focused on Blockchain technology in the participating countries") has shown that most higher education curricula for Waste Management are still of disciplinary nature (mainly Civil Engineering, but circular waste-to-resource management training offers from other disciplines e.g. Business Studies, Environmental Studies, Sustainability Studies (see for details: BlockWASTE deliverable "O2/A1.1 Comparative study of the curricula focused on Blockchain technology in the participating countries") and especially private-sector training programmes have pioneered a cross-disciplinary shift. This is the impulse that the Blockwaste curriculum tries to support.

1.3 Objectives and methodological approach

1.3.1 Educational context, purpose of the Curriculum and embedding into wider educational and training programmes

As the future context of learning and teaching for waste management will reflect the ongoing changes in industrial manufacturing (Mavropoulos & Nilsen, 2020) known as Industry 4.0, curricula will need to cross long-inherited strict disciplinary boundaries such as Civil Engineering. Data Analytics, IT and Distributed Ledger Technologies / Blockchain, Value Cycle Analysis, Public Administration Management, Change Management etc need to become part of the syllabus. This reflects demand and opens room for specialization within the scope of curricula. Considering the heterogeneity of the target groups mentioned in a following section, the curriculum has been conceived so as to allow learners to combine and study a subset of individually selected modules. All modules are self-contained and most of them enable Waste Management staff to acquire specific change-relevant skills for Circular Economy approaches. The curriculum does not, on the other hand, re-address basics of (linear) waste management that the target groups are thought to have acquired before.

This is what will make 'smart' embedding of module and curriculum content into wider degree or training programmes crucial for planners. Supporting integrated curriculum development for urgently needed education and training of expert and management staff in the circular shift of waste-to-resource requires technological, organizational, management, cultural and communication innovation.

The Blockwaste curriculum is to address this mid-term and long-term need without neglecting present-day 'linear' realities evolving towards circular processes. It offers basic skills in Blockchain-based MSWM (12 ECTS). In academic contexts, however, a full curriculum could be offered as a 30 ECTS (European Credit Transfer System) elective or as a building block of a wider 60 ECTS Master's programme e.g., in Circular Economy and Waste Management.

Individual modules can also be integrated as components of wider master's degrees such as Sustainable (Materials) Management or Circular Economy, Sustainability Studies among others. When used for industrial training, individual or sets of modules can be studied and certified independently.

Embedding or add-on options of the Blockwaste curriculum can thus be:

- Initial vocational training: add-on of selected and adapted modules to approved curricula of recognised occupational profiles of the waste and utilities sector
- Industrial further training: specialisation training in Waste Management (design and execution of cycles) and circular economy as an add-on skill or skills upgrade, often as part of wider programmes
- Academic education:
    - Add-ons to or electives of Engineering, Business / Economics and related degrees
    - Individual modules integrated into full-size Master's degrees (as often practised in Civil Engineering);
    - Full integration of the set of modules into Environmental Engineering Master's degrees
    - Core modules integrated in (Sustainable) Business degrees with a strong focus on CE
    - Set of modules as elective on wider Resource Management or also Applied IT degrees

1.3.2 Target groups

The Blockwaste curriculum is addressed to public and private-sector Waste Management and public utilities staff in manual, technical, administrative and management positions. Its full-size deployment targets future decisionmakers in the waste sector, technical/engineering (civil / mechanical / process / mining and extraction engineering / material sciences / biochemistry) and management staff of the waste industry, of manufacturing industries and equipment suppliers. It is also addressed to (future) consultants and environmental engineering students and experts, economists and graduate economics / business students.

1.3.3 Entry qualifications

The curriculum is mainly designed for upper technical / administrative and management staff of the waste sector. Certain modules can, however, be used for training vocational staff with sufficient work experience in waste management organisations.

a. Vocational level: Vocational diploma and experience in public administration, engineering, chemistry, manufacturing, materials management, mining, logistics, business administration, IT and digital services and administration, agriculture, textile, craft and food technology

b. Academic level: First degree in Engineering, Chemistry, Materials Studies, Agricultural Management, Agro-Economics, Environmental Sciences and Engineering Logistics, Economics, Business, Public Administration, IT.

1.3.4 Teaching and learning, customization and adaptation

When implementing a curriculum such as the Blockwaste curriculum, training managers and lecturers may apply 'agile learning' modes allowing learner-centered styles, open curricula and project-based learning (Krehbiel et al., 2017). It is true that the waste industry with its numerous stakeholder interfaces has a high need for agility and readiness for change. This will require a revolution in learning culture, but developments in this direction have only started emerging and will be gradual. This has kept the ambition of the Blockwaste consortium in check so that the present curriculum also reflects the needs expressed in learning and curriculum approaches found 'on the ground' (see also for details: BlockWASTE deliverable "O2/A1.1 Comparative study of the curricula focused on Blockchain technology in the participating countries").

1.3.5 Recommendations on curriculum delivery

For practical purposes and implementation of the curriculum, the Blockwaste consortium makes the following recommendations to degree, programme and training managers.

Sequencing and combination of modules

All modules outlined here can be delivered stand-alone or as a set or a combination of modules. Choice will depend on the target group's background and skills levels. As skills levels will inevitably vary among a group (especially in industrial training), we recommend a large portion of coached self-study to be considered in the delivery.

Embedding into wider curricula

All modules can be integrated into wider curricula (e.g., Waste and Water Management on a Civil Engineering degree) but will then need to be smartly interfaced to avoid redundancies or gaps. This may be the case especially with highly specific content like data analytics. When embedded into more generalist / transversal programmes such as Sustainability Management or Environmental Technologies, certain modules, especially the IT-focused ones, could be offered as electives.

Open and agile curricula

All modules can be taught / studied in a conventional classroom setting. If more innovative approaches to learning design are chosen such as project-based (digital) learning or consistent learner-centeredness (inverted classroom, peer-to-peer learning), participants' research can be made the centre of the course so that a module's topics are distributed among participants for self-study supported by reading and link lists and coaching by lecturers. For this, involvement of waste and materials industry players in the research undertaken by those participants that operate in an academic environment would add considerable value to the curriculum. This exposure to 'waste realities' would also provide hints at necessary updates to the curriculum and new research necessities that will, considering the pace of change, inevitably become part of the learning agenda.

Occupational profiles and certification

The Blockwaste modules are designed to become part of academic programmes. For industrial training purposes, certification will need to be co-ordinated with EU or national taxonomies varying from country to country.

As most academic contexts require lengthy curriculum update procedures under the currently prevailing conditions, it is advised to keep the wording of descriptions going into module catalogues etc. relatively general and updatable.

For use in initial vocational training, module content should be compacted and lead to final outputs like checklists or practical, action-oriented summaries that can be tested and certified according to vocational standards.

2 Blockwaste Curriculum modules

2.1 Module 1 - Waste management and Circular Economy

Module /content name	**Module 1** **Waste management and Circular Economy**		
ECTS	3	**Number of hours**	75
Productive Sector	Generic, focus on waste industry		
Formal qualifications, entry profile	BSc / BA in ○ Civil Engineering ○ Building Engineering ○ Mining Engineering ○ Geology ○ Environmental Engineering ○ Sustainability Engineering ○ Sustainable Business and Management ○ IT Engineering ○ Data Science		
Job positions	-Environmental Consultant -Environmental Technician -Manager or Construction Site Director -Mining Manager -Manufacturing Manager -Waste manager -Consultants for Circular Economy and Waste Economics		
Module learning objectives	Increasing the skills and qualifications of active workers (bachelor level) to improve their adaptation to the labour market towards the transition to a green economy to achieve smart, sustainable and integrated growth in the waste management sector. This Circular Economy Course and MSW management module is multidisciplinary and applied, aimed at anyone seeking to kick-start circular economy and waste management.		
General competences and specific competences	GC 1. Having a broadly based understanding of the concept and functioning of a Circular Economy with specific regard to waste streams SC 1.1. Understanding possible health and environmental hazards of waste substances		

	SC 1.2. Being aware of the impact and the requirements the emerging transition from a linear to a circular economy brings SC 1.3. Understanding the technological options available for supporting a Circular Economy SC 1.4. Integrating the flow of both substances and data into any modelling of substance cycles SC 1.5. Having a sound understanding of legal frameworks of waste management and the Circular Economy at national and EU levels
	GC 2. Well-founded understanding of the theoretical and practical aspects and working methodology in the field of the Circular Economy. SC 2.1. Know the principles of sustainable development applied to municipal waste management. SC 2.2. Carry out operations at all times prioritizing the Circular Economy and sustainable processes. SC 2.3. Adopt the environmental measures established for the prevention to damage the environment.
	GC 3. Be able to predict and control the evolution of complex situations through the development of new and innovative work methodologies adapted to the field of Circular Economy. SC 3.1. To know the advantages and disadvantages of the waste treatment approaches and to be able to evaluate which treatment approach is economically and environmentally profitable. SC 3.2. To be able to apply circular models to MSW management. SC 3.3. To understand and apply new technologies in order to improve the circular processes associated with MSW management. SC 3.4. Ability to apply ethical criteria and sustainability in decision making.

	GC 4. Be able to take responsibility for their own professional development and their specialization in Environmental Engineering, Circular Economy and Sustainable MSW management processes. SC 4.1. Knowledge of the impact of MSW management on the achievement of sustainable development and, especially, deepening the knowledge of the regulations and policies from the point of view of circular economy. SC 4.2. Knowledge of the techniques for assessing the environmental impact of MSW treatment approaches. SC 4.3. Ability to reconcile environmental requirements with the conditions of sustainable development.
	GC 5. Be able to foster, in professional contexts, the technological, social or cultural advancement within a society based on knowledge. SC 5.1. Know the different tools of environmental management, as well as its correct application to reduce environmental problems of MSW management. SC 5.2. Ability to manage computer tools that allow data management, problem solving and help decision making.
	GC 6. Be able to take responsibility for their own professional development and their specialisation in one or more fields of study. SC 6.1. Plan the implementation of an environmental management system, as well as coordinating and maintaining through advances of new technologies.
	GC 7. Understanding and applying the legal frameworks that govern the Circular Economy and waste management. SC 7.1. Understanding waste classifications and waste hierarchy principles SC 7.2. Being aware of all relevant standards and norms applying to the Circular Economy and waste management SC 7.3. Being familiar with all relevant certificates and certification procedures

Syllabus: Teaching units and skills	**Teaching Unit 1. Introduction to Municipal Solid Waste** TU 1.1. Definition TU 1.2. Classification of MSW. Categories of municipal waste, according to Eurostat (2017). TU 1.3. MSW stream characteristics 1. Methods of Characterizing MSW 2. Materials in MSW by Weight 3. Discards of MSW by Volume 4. Variability of MSW Generation TU 1.3. MSW and the environment 1. Quantities of MSW 2. Emission of Pollutants from MSW 3. MSW Management and Climate Change 4. MSW management and Public Health
	Teaching Unit 2. Introduction to MSW management TU 2.1. Introduction to MSW management 1. Waste generation and management issues 2. Integrated waste management 3. Typical costs for main waste management options TU 2.2. Waste management hierarchy Prevention, Preparing for Re-Use, Disposal, Recovery, Recycling TU 2.3. Common principles in MSW management Affordability, polluter pays and sustainability
	Teaching Unit 3 MSW treatment TU 3.1. Landfill TU 3.2. Incineration and energy recovery TU 3.3. Composting and biomethanisation TU 3.4. Recycling

	Teaching Unit 4 Introduction to CE TU 4.1. Introduction to Circular Economy TU 4.2. The linear model of production and consumption TU 4.3. Circular economy: concept, origins and principles TU 4.4. Circular economy vs. linear economy TU 4.5. Challenges and benefits of circular systems
	Teaching Unit 5 MSW management in a CE TU 5.1. Conceptual outline of the circular economy in the MSW management sector 1. Definition of circular economy and its importance in the MSW management sector 2. Evolution of the MSW management sector towards the circular economy TU 5.2. Development of the circular economy in the MSW management sector 1. Roles of MSW management sector agents in the circular economy 2. Challenges and barriers in the development of the circular economy in the MSW management sector
	Teaching Unit 6 Technologies for a circular MSW management TU 6.1. IoT TU6.2. Robotics TU 6.3. Sensoring TU 6.4. Track-and-trace TU 6.5. Treatment processes and equipment
Teaching methods	Lectures and seminars will be organized for the theoretical content. In the seminars, specific topics of the theoretical syllabus will be expanded. Resolution of practical cases. Problems are posed to students for their individual resolution. Tutorials will be organized for the resolution of individual or group doubts about theory, problems, practices and seminars.

	Multimedia didactic resources will be used when they are available. Lessons should be complemented with the visit to different type of natural stone companies.

2.2 Module 2 - Blockchain

Course /content name	**Module 2** **Blockchain**		
ECTS	3	**Number of hours**	75
Productive Sector	Generic		
Formal qualifications, entry profile	- BSc / BA in ○ Civil Engineering ○ Building Engineering ○ Mining Engineering ○ Geology ○ Environmental Engineering ○ Sustainability Engineering ○ Sustainable Business and Management ○ IT Engineering ○ Data Science		
Job positions	○ Environmental Consultant ○ Environmental Engineer ○ Manager or site engineer ○ Waste / Recycling Manager ○ Manufacturing Manager ○ IT hardware or software specialist / engineer or similar position		
Module learning objectives	The aim of the course is to develop an in-depth understanding of the problems for which blockchain technology is suitable and the main advantages but also the risks and disadvantages it entails. In addition, the participants should understand the interplay between the blockchain as a decentralised transaction database and the Internet of Things, Big Data Analysis, and Artificial Intelligence, and be able to integrate them into their own work. The blockchain requires the transfer of tokens as representatives of digital values. In this respect, it is essential that learners recognise which real underlying values can be digitally represented as tokens for which purpose. The aim of the entire course is to impart		

	practical knowledge so that the participants are able to start blockchain projects.
General competences and specific competences	GC 1. Understand the functioning of Blockchain technology SC 1.1. Gain an understanding of Peer-to-peer, Client-server and Hybrid networks SC 1.2. Gain an understanding of basic concepts like double-spending, Proof-of-Work and decentralisation SC 1.3. Understand the benefits and risks of Blockchain applications
	GC 2. Gain an in-depth understanding of Blockchain 2.0 and smart contracts SC 2.1. Know the difference between Blockchain 1.0 and 2.0 SC 2.2. Gain knowledge of Ethereum and Smart Contracts
	GC 3. Gain an in-depth understanding of Blockchain types SC 3.1. Know the difference of Blockchain consensus protocols SC 3.2. Gain knowledge of Blockchain governance SC 3.3. Gain knowledge of Blockchain platforms and consortia
	GC 4. Gain an understanding of cryptocurrencies and tokens SC 4.1. Learn about tokens and be able to tokenise the material flow of supply and waste chains by using stable coins and crypto currencies Sc 4.2. Learn about the classification of Blockchain tokens and fund acquisition tokens
	GC 5. Be able to solve simple Blockchain problems using simulation games
Syllabus: Teaching units and skills	**Teaching Unit 1. Blockchain Fundamentals** TU 1.1. Peer-to-peer network TU 1.2. Client-server network TU 1.3. Hybrid networks: the case of Napster TU1.4. Blockchain TU 1.5. Double-spending TU 1.6. Proof-of-Work

	TU 1.7. Decentralisation TU 1.8. Privacy
	Teaching Unit 2. Blockchain 2.0 and smart contracts TU 2.1. Blockchain 1.0 and 2.0 TU 2.2. Ethereum TU 2.3. Smart Contracts TU 2.4. Decentralised applications and autonomous organisations
	Teaching Unit 3 Types of Blockchain TU 3.1. Types of Blockchain according to consensus protocol TU 3.2. Blockchain governance TU 3.3. Platforms and consortia
	Teaching Unit 4 Cryptocurrencies and tokens TU 4.1. Crypto economics TU 4.2. Classification of Blockchain tokens TU 4.3. Fund acquisition tokens
	Teaching Unit 5 Uses and applications of Blockchain T.U5.1. Business models TU 5.2. Enterprise Blockchain applications TU 5.3. Conditions to implement Blockchain successfully
	Teaching Unit 6 Blockchain simulation games TU 6.1. The modified "Blockchain game!" TU 6.2. The Interactive Blockchain simulator
Teaching methods	Lectures and seminars will be organised for the theoretical content. In the seminars, specific topics of the theoretical syllabus will be expanded. Resolution of practical cases. Problems are posed to students for their individual resolution. Tutorials will be organized for the resolution of individual or group doubts about theory, problems, practices and seminars.

	Multimedia didactic resources will be used when they are available.

2.3 Module 3 - Blockchain-based Municipal Waste Management

Course /content name	**Module 3** **Blockchain-based Municipal Waste Management**		
ECTS	3	**Number of hours**	75
Productive Sector	Generic		
Formal qualifications, entry profile	BSc / BA in ○ Civil Engineering ○ Building Engineering ○ Mining Engineering ○ Geology ○ Environmental Engineering ○ Sustainability Engineering ○ Sustainable Business and Management ○ IT Engineering ○ Data Science		
Job positions	○ Environmental Consultant ○ Environmental Engineer ○ Manager or site engineer ○ Waste / Recycling Manager ○ Manufacturing Manager ○ IT hardware or software specialist / engineer or similar position		
Module learning objectives	The aim of the module is to guide professionals in the waste management sector on how they should implement IoT and Blockchain technology as strategies of Circular Economy. Practitioners need to know about the advantages of using the Blockchain technology as well as having a sufficient understanding of the Circular Economy and its goals. In this direction they need to understand the changing role of municipal solid waste management (MSWM) in the context of Circular Economy (CE) and how Blockchain technology can facilitate the need for change in various aspects. The learners must also understand how to implement Blockchain Technology and to convert existing processes into Blockchain-based processes. Finally, they need to identify the best uses of Blockchain and smart contract technologies within the waste sector through the application of these innovative technologies in municipal and local corporate organisations.		

General competences and specific competences	GC 1. Understand the fundamentals of using Blockchain technology in waste management sector SC 1.1. Gain an understanding of how they should implement Blockchain technology as strategies of Circular Economy SC 1.2. Learn about the advantages of using the Blockchain technology SC 1.3. Understand how Blockchain facilitates data sharing in the Circular Economy
	GC 2. Gain an understanding of the role of data management in MSWM SC 2.1. Understand the importance of data integrity and data protection SC 2.2. Learn about data collection processes in MSWM operations SC 2.3. Learn the basics about MSWM data analytics SC 2.4. Learn about the changes in operations and processes of MWM through Blockchain
	GC 3. Gain an in-depth understanding of the changing role of MSWM in the context of CE and the contribution of Blockchain technology SC 3.1. Understand the changes in operations and processes of MSWM SC 3.2. Learn about the changes in operations and processes of MWM through Blockchain SC 3.3. Learn how automation can be enhanced by IoT & Smart Contracts and Blockchain SC 3.4. Understand how Blockchain can act as facilitator of P2P-collaboration
	GC 4. Be able to design and manage Blockchain-based MSWM projects SC 4.1. Be able to identify the stages and processes of Blockchain transformation in MSWM SC 4.2. Be able to design the stages and processes of Blockchain transformation in MSWM SC 4.3. Be able to monitor Blockchain-based transformation in MSWM by means of appropriate indicators
	Teaching Unit 1. MSWM transformation in the context of CE

Syllabus: Teaching units and skills	TU 1.1. How and why MSWM changes in the context of CE TU 1.2. The role of data collection and management in the transformation of MSWM TU 1.3. The role of Blockchain technology in the transformation of MSWM TU1.4. The role of MSW managers in the transformation of MSWM
	Teaching Unit 2. Issues to concern in MSWM transformation TU 2.1. Value creation of MSWM TU 2.2. Step-by-step changes in operations and processes of MSWM TU 2.3. The role of trust between the different actors TU 2.4. Enhancing automation by IoT & Smart Contracts and Blockchain TU 2.5. The role of Blockchain as facilitator of P2P-collaboration
	Teaching Unit 3. Design and manage Blockchain-based MSWM projects TU 3.1. Stages of a Blockchain project TU 3.2. Identification of a suitable process for Blockchain conversion TU 3.3. Design of a Blockchain-based process TU 3.4. Monitoring a Blockchain-based process using appropriate indicators TU 3.5. Development of a governance model for Blockchain applications TU 3.6. Convincing the top management
Teaching methods	Lectures and seminars will be organized for the theoretical content. In the seminars, specific topics of the theoretical syllabus will be expanded. Resolution of practical cases. Problems are posed to students for their individual resolution. Tutorials will be organized for the resolution of individual or group doubts about theory, problems, practices and seminars.

	Multimedia didactic resources will be used when they are available.

2.4 Module 4 – Project-based learning of MSWM and the role of Blockchain

Course /content name	**Module 4** **Project-based learning of MSWM and the role of Blockchain**		
ECTS	3	**Number of hours**	75
Productive Sector	Generic		
Formal qualifications, entry profile	BSc / BA in ○ Civil Engineering ○ Building Engineering ○ Mining Engineering ○ Geology ○ Environmental Engineering ○ Sustainability Engineering ○ Sustainable Business and Management ○ IT Engineering ○ Data Science		
Job positions	○ Environmental Consultant ○ Environmental Engineer ○ Manager or site engineer ○ Waste / Recycling Manager ○ Manufacturing Manager ○ IT hardware or software specialist / engineer or similar position		
Module learning objectives	The aim of the module is to offer users several keys to achieve the integration of Blockchain-based MSW and help them understand the whole traceability and visibility of municipal solid waste from the beginning to the end of their management. This module runs as a tutored project hypothetically hosted by a waste management organisation (namely, a Municipality), using an interactive role-playing game, which is based on two roles, i.e., the 'mayor' (assumed to be in charge of the MSW management authority) and the 'households'. Input data are based on real-life data and address real-life problems. The main objective for the learners is to acquire planning and conceptualising skills for digitalised waste management, recycling and circular economy processes by making decisions in a collaborative environment, which helps them to visualise		

	how the encrypting of information of a Blockchain works. In this context, the learners will: • Understand digital, data-driven infrastructure like IoT, Blockchain and others in waste management and circular economy • Apply process management skills to waste / substance cycles and to data administration • Apply stakeholder analysis skills to specific waste cycles and value chains • Upgrade skills in communicating and promoting key elements of digital transformation of the waste industry in teams and across departments and hierarchies
General competences and specific competences	Given the holistic character of the project, competences addressed are acquired along the project rather than in isolated topical units. Furthermore, coaching services ensure candidates can develop soft skills in the project process. Nevertheless, some general and specific competencies are specified as follows.
	GC 1. Understand the fundamentals of MSWM economics SC 1.1. Gain an understanding of how the collection, treatment and disposal cost is estimated SC 1.2. Learn about the different treatment approaches and their cost implications SC 1.3. Understand how waste management authorities estimate and decide about waste management fees SC 1.4. Realise the differences in waste management costs for mixed and separated waste
	GC 2. Understand the fundamentals of MSWM processes SC 2.1. Gain an understanding of how mixed and separated waste are treated SC 2.2. Learn about the impact of alternative treatment options on CE targets
	GC 3. Understand how the Blockchain interferes with the MSWM processes SC 3.1. Gain an understanding of how Blockchain can be used to anonymise the information SC 3.2. Find out the benefits of Blockchain in building trust among the MSWM actors

	GC 4. Develop soft skills, e.g.: • Data mining and analysis in MSW and materials cycles: KPIs, data collection, data storage, data analysis, data value creation and tradability, data sharing • Analysing existing organisational structures and re-designing parts of an organisation for CE purposes relating to MSWM technical and economic operations • Flexibility and adaptiveness • Understanding of complexity of economic decisions • Communicating and advocating innovation with both respect and enthusiasm • Inclusive strategies in team communication ahead of changes in organization • Defining objectives, stakeholder mapping and communication, process ownership, output/outcome planning, resource planning, indicator definition, validation, iterations
Syllabus: Teaching units and skills	**Teaching Unit 1. Playing the "Interactive BlockWASTE Tool"** TU 1.1. Using the information collected within the MSW database TU 1.2. Assigning roles to the class group TU 1.3. The role of 'households' TU 1.4. The role of the 'mayor' TU 1.5. Playing the game TU 1.6. Discussing the results at the end of the game
Teaching methods	The module runs with a co-operative learning approach, using an interactive role-playing game. Workload will mostly be delivered in a lab-type environment on campus or online. Students' work will consist of modelling and conceptualising issues relating to waste management treatment options and their economic and environmental implications and will be coached by lecturers. Occasional input, e.g., on Blockchain applications or Data Analytics, will be provided in workshop form when necessary (in order to demonstrate the interface of waste management and Blockchain, a simple Blockchain problem is included - the user must solve the problem first in order to submit input data to the municipal authority). Students will work on adequate technological solutions, data generation and handling but also on waste producer and waste authority communication.

3 Bibliography

Bozkurt, Ö., & Stowell, A. (2016). Skills in the green economy: Recycling promises in the UK e-waste management sector. *New Technology, Work and Employment*, *31*(2), 146–160. https://doi.org/10.1111/ntwe.12066

Directive 2018/851. (2018). *Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste*. https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32018L0851

Krehbiel, T. C., Salzarulo, P. A., Cosmah, M. L., Forren, J. P., Gannod, G. C., Havelka, D., Hulshult, A. R., & Merhout, J. W. (2017). Agile Manifesto for Teaching and Learning. *The Journal of Effective Teaching*, *17*, 90–111.

Laloux, F. (2014). *Reinventing Organizations: A Guide to Creating Organizations Inspired by the Next Stage of Human Consciousness*. Nelson Parker.

Mavropoulos, A., & Nilsen, A. W. (2020). *Industry 4.0 and Circular Economy: Towards a Wasteless Future or a Wasteful Planet?* Wiley.