An Interdisciplinary Approach in Education of Master Students in Intelligent Sustainable Habitats

Theodoros Kosmanis[1], Dimitrios Tziourtzioumis[1], George Katranas[2], Žaneta Stasiškienė[3], Rossitza Goleva[4,5(✉)], and Arianna Azzellino[6]

[1] International Hellenic University, Alexander University Campus, Sindos, Greece
{kosmanis,dtziour}@ihu.gr
[2] Cerca Trova Ltd., Sofia, Bulgaria
katranasg@ctrova.eu
[3] Žaneta Stasiškienė, Kaunas University of Technology, Kaunas, Lithuania
zaneta.stasiskiene@ktu.lt
[4] New Bulgarian University, Montevideo Str. 21, Sofia, Bulgaria
rgoleva@gmail.com
[5] InterConsult Bulgaria, Indzhe Voyvoda Str. 7, Sofia, Bulgaria
[6] Department of Civil and Environmental Engineering, Politecnico di Milano, Milano, Italy
arianna.azzellino@polimi.it

Abstract. This paper presents an interdisciplinary approach in education in intelligent sustainable inhabitance that proposes a distance-to-semi-distance approach . The paper demonstrates the way the syllabus is prepared and all difficulties in its implementation on the European market of education. The work is inspired by the high demand of the market for employees with different skills that are capable not only of deploying the Internet of Things solutions but also to design, redesign, maintain, configure, and program them. Special collaboration with the small, medium, and large companies is made in the consortium to ensure that the projects of the students will come from the real business environment. The syllabus is created, courses are developed with special support from the business, and the legislative problems are studied carefully. The program will be ready to start at the beginning of 2025 with applicants from all over the world.

Keywords: Sensors · Actuators · Internet of Things · Sustainability · Digital Twins · Data Sharing · Edge-Fog-Cloud Continuum · Legislation in Education · Certification vs. Real Master Curriculum

1 State of the Art

Over the last two decades, the importance of the Internet of Things (IoT) and its implementation in many sectors related to our lives has become increasingly critical. Young generations are looking more often to the possibility of having sustainable living conditions and trying to educate the children to follow the same approach. The increase in

T. Zlateva and G. Tuparov (Eds.): CSECS 2024, LNICST 609, pp. 332–346, 2025.
https://doi.org/10.1007/978-3-031-84312-9_22

Greenhouse gas emissions and the average temperatures rising on Earth are driving forces in this process. IoT is not only a technological solution for making the living environment sustainable. As technologies evolve, network intelligence increasingly shifts towards the edge, enabling more efficient and localized processing and decision-making.

The way the applications support the sustainability of the inhabitants is distributed in the edge-to-cloud continuum and the integration of services, data distribution and data sharing, the spreading of the artificial intelligence analyses and cooperative use of resources are becoming key technological factors for the success of the technology on the market.

Digitalization of different systems creates a new business opportunity for the professionals in information and communication technologies to create services at all levels of the network. The capability improvement of the edge devices such as controllers, gateways, switches, and routers allow the transfer of intelligence to the periphery of the network and the implementation of not only machine learning algorithms at the edge devices but also of digital twin technology locally and services' adaptation to the circumstances. Such implementation requires new ways of data fusion and data management in the network. IoT implementations cover many sectors including the smart way of living and smart way to work.

Connectivity via 6G interfaces aims to be highly distributed with high capacity and independent from the service providers [1]. Virtual networks per customer might be constituted using direct peer-to-peer interfaces as well as Machine-to-Machine (M2M) interconnections. Interoperability between different parts of the platforms and infrastructure is becoming an important part of the tasks to be solved and is going to be supported by well-defined standards. The automation of many of the services aims to be supported without human intervention. The solutions are expected to be safe and efficient. Productivity in establishment and maintenance implemented by new generations of employees is important [2]. The economic impact of the Internet of Things implementations is expected to be measured in trillions per year, i.e., about 10% of the world economy [3, 4]. Seventy five percent of the population of Europe lives in cities [5] nowadays and it is going to increase due to the quality of life, resources, and the infrastructure [6].

Smart urban sustainability systems can provide a vital tool to many areas such as:

- Retail
- Banking & financial institutions
- Telecom [1]
- Information Technology (IT) [24, 25]
- Industry 5.0 [1]
- Healthcare
- Automotive
- Oil & gas supply
- Energy supply [7–9]
- Transportation
- Circular economy
- Renewable energy
- Recycling waste/e-waste [10–14]
- Smart cities [15–18]

- Smart environment [19–21]

End-users, stakeholders, and big players are becoming decision makers based on the vast amount of information that is gathered, processed, and visualized [22]. The information could be collected dynamically. It could be also processed dynamically for optimization of different processes in the living environment. Machine learning, virtual reality, digital twin technologies could be used not only for optimization of existing processes but also for prediction of events including disastrous events and planning of preventive measures. It is expected to lead to the optimal use of natural resources and reduction of the carbon footprint and resource/energy waste.

IoT adaptation to the market depends on the new sensing and data gathering technologies. This increases the requirements for the education of engineers, programmers and technicians, to be flexible in adaptation to the market almost in real-time.

The European Union programme Horizon2020 funds projects in billions of Euros for the development of IoT technologies and all correlated ICT topics [15, 16, 23]. Many calls for different scale of pilots in IoT, integration and interoperability through the cloud-to-edge continuum are supported including Smart Urban ICT/IoT technology development [17]. The placement of the services for the citizens is becoming transparent in time, space and resources used for storage and processing of the data. A very special segment of the market is Industry 5.0, where robots and people work together and where the requirements for skills in security and reliability as well as risk analyses are high.

The aim of the project INHABITAT and created syllabus on IoT is to prepare professionals with the necessary variety of skills to solve the problems in the vastly developing IoT market segment.

There is a need for knowledge in digital technologies, programming, electronics, system design, virtual reality, IoT, green technologies, safety and risk analyses, machine learning. Such personnel are expected to work for the sustainability of the solutions in service creation and design of the ecosystem, data distribution, and processing [18].

The current players on the IoT market employ people with different skills and try to build interdisciplinary teams of:

- Civil engineers
- Urban and regional planners
- Computer engineer
- Electrician
- Electronics engineer
- Energy engineer
- Transportation, storage, and distribution managers
- Recycling coordinators
- Occupational health and safety specialists
- Geospatial scientist and technologist
- Industrial engineer
- IT specialist
- Environmental compliance inspectors
- Renewable energy manager
- Industrial ecologists
- Transportation engineer

- Waste water resource specialist

These professionals possess good skills in their specific areas but struggle to correlate their work with the effort of the other team members.

True teamwork can only be achieved by training people in additional skills that enable them to understand and effectively address interdisciplinary problems.

With the proposed syllabus, the aim is to fill this gap and have professionals in the field ready to implement the technologies immediately after graduation. This makes the syllabus broad in the range of topics selected and trained upon. As some of the sectors are considered critical, such as pollution monitoring, waste/e-waste handling, resource management and protection (water, soil, air), green cities (transport, energy) and renewable energy production the syllabus could be enhanced and implemented with different stress on these subjects.

Recent reports from the USA emphasize the knowledge gap in the business ecosystem for optimizing their resources and infrastructure to the current IoT or its potentials to be revealed soon. The scientific literature also identified significant potential for IoT uptake, despite many industries already enabling IoT within their process (e.g., agriculture, manufacture), though to a greatly variable degree. Many sectors act "status quo" without significant improvements or technology uptakes (the "head-in-the-sand" syndrome), likely due to a lack of knowledge and a systemic shortage of targeted educational programs for engineers and technicians to cater and safely handle IoT technology concept. The European Commission is fully aware of these obstacles and needs. According to the Europe′s Internet of Things Policy, the single market for IoT depends strongly on the capability to operate with diverse and large number of devices interconnected securely. It is a fact that the educational needs required to tackle them are also lacking.

Currently, only a few European universities offer courses and/or degrees in industrial IoT, mostly as an interdisciplinary bachelor′s degree programme [24–28]. Most of the offered programmes combine the study of electronic engineering and computer science, and refer partially to Internet technologies, wireless communications, sensor devices, and cloud computing. In our study we identify the nine most in-demand IT skills for new IoT programme such as:

- Artificial intelligence
- Augmented and virtual reality
- Blockchain
- Cloud-to-edge computing
- Cybersecurity
- Big data science
- Sensing technologies
- Robotic process automation
- User interface/experience design

While the business is adapting quickly to the market requirements it is not the case for the universities. Many legislative problems are present in all EU member states, preventing the quick implementation of a syllabus at universities and flexible adaptation to the market. In our case the legislation in Greece, Bulgaria, Romania, Spain, Latvia, Lithuania, Germany, Austria, France, Italy was studied. It is found that the fastest and

more efficient route to the program accreditation is established in Lithuania among the selected countries. Furthermore, the legislation procedures in the countries are not harmonized, regardless of the Bologna process. There is a long way to be followed until the moment the students can freely move between courses and universities.

Our Partnership proposes a specialized, innovative, cross-functional curriculum focused on how the Internet of Things (IoT), advancing data into wisdom, and Smart City technology can positively affect sustainability. It will use interactive teaching methods and provide a solid grounding for the increased demand for careers in their industry or the growing field of sustainability. Aside from helping individual students, this curriculum will help prompt local communities and authorities to embrace these new technologies to help with the industrial application of social and ecological responsibility, benefiting a circular and more sustainable economy.

The output of the partnership is to design courses that will give additional skills in Smart Urban Systems. An adaptive MSc degree and micro-certificate programmes are created with long term vision of the labor market. The co-developed syllabus between Higher Educational Institutes (HEIs) and industry offers also a Vocational Education and Training (VET). The form of micro-credentials/micro-certificates to those who wish to gain specific skills for up-skilling and life-long education is proposed.

For this purpose, four academic institutions, one VET provider and seven high-tech ICT/IoT Small and Medium Enterprises (SME's) and one MSc certification SME, residing in Austria, Bulgaria, France, Germany, Greece, Italy, Latvia, Lithuania, Romania and Spain joined to create joint course named: INtelligent sustainable HABITATs master's course (INHABITAT). The courses will be taught remotely while the practical training is going to be provided on site.

In our work, we present the idea of the syllabus and the organizational problems we must solve to make it valid. The work is inspired by the many pilots in IoT implementations and clear market analyses.

The paper is organized as follows. A literature analyses is presented, the international significance of the syllabus and program is explained, the technical scope of the syllabus, the structure, the training possibilities, expected results and analyses of the outcomes are defined at the end.

2 International Significance of the Program

The unique thing in the proposed innovative curriculum in the field of Smart Urban Sustainability IoT systems is the cross-sectoral interactive teaching methods and partnerships. The first implementation of the syllabus will be at Kaunas University, Lithuania where the flexibility in adapting the teachers and professional working on the syllabus has high level of freedom. This first implementation for the students from all over the world will demonstrate how adaptable to the market the program could be having in hand a big team of professionals and educators along the entire Europe.

The INHABITAT aims are to:

– Develop an innovative course on Digital & Green skills.

  This task is fulfilled by a joint venture between the industrial and academic partners. For example, the courses on remote measurement systems and Augmented

Reality (AR) including a laboratory enable students to collect data and get start with AR models that large industrial corporations are currently developing, and to teach them how to use drones as a remote measurement system. The course does not depend solely on virtual laboratories that are widely used in chemistry and physics. Instead, they will depend on hands on training, gain experience from real-time reconfigurable laboratory apparatus, cultural and educational exchange through the mobility periods and most importantly the 1-month of hands-on industrial experience in developing, installing, and monitoring an industrial grade measurement system in real-life conditions.

– Boost innovative thinking and ignite entrepreneurship by interactive teaching and industrial support.

  The syllabus is intended not only for master students but also for professionals that need a vocational education, certification, and skills' that are the main actors in the entrepreneurship process. Entrepreneurs and, thus SMEs, are the key factor to ensuring economic growth, innovation, rise of employment, and social integration in the EU. The variety of the sectors implementing IoT solutions, and the diversity of possible implementations open new opportunities to SMEs to create jobs. Educating an individual to the concept of entrepreneurship is all about creating the ability of individuals to turn ideas into action. Educators need to foster creativity, out of the box thinking, risk-taking and management skills to achieve their goals.

– Address participants from different social groups to interwork and create a multicultural working environment.

  In many cases such as disability, health problems, educational difficulties, cultural differences, economic obstacles, social obstacles, or geographic obstacles the people may not be capable of participating in full time education. In response, the consortium will be committed to inclusion, diversity and equity and follow the EU guidelines on selecting the students, planning and carrying out a successful inclusion project that is also addressed to people with fewer opportunities. The European Commission is investing in several initiatives for improving the access of people with a migrant background and migrants to education and skills acquisition/recognition from school age and beyond.

– Break further the boundaries for the digital nomads by enhancement of cross-border academia/industry cooperation

  With flexibility in teaching proposed by Kaunas University, the consortium can cover all teaching and training courses with a high degree of reserve and thus aiming sustainability in the support of the program.

– Create an MSc courses based on the ECTS credit system that is recognized by academia and industry throughout the EU

The INHABITAT course is an activity towards shortage of skills and personnel in IoT implementation in Southern and Eastern Europe. The market growth and high societal needs are addressed by the designed and developed innovative curriculum.

Open and online, blended, work-based, multi-disciplinary learning and new assessment models are combined uniquely. The aim is to enhance the digital competencies of possible social groups that could join the IoT professionals' group and ignite entrepreneurial thinking.

The program will focus on improving the three major types of skills related to the IoT for Urban Sustainability applications:

- Digital skills – the focus of the proposed syllabus and curriculum is smart, connected IoT systems, therefore digital skills are at the core of INHABITAT approach, as demonstrated by several specific objectives
- Green skills – the main application field of INHABITAT is on smart systems for urban sustainability, therefore green skills enhancement is the key factor to the project's success.
- Resilience is an important aspect of ensuring the long-term impact of the project.

3 Technical Scope of the Programme INHABITAT

The technical scope of INHABITAT program and syllabus is based on the cloud-to-edge continuum. The architecture of the platform that inspires the content of the syllabus is presented in Fig. 1. A typical Internet of Things (IoT) solution is shown. It could be integrated through existing communication technologies such as 4G, 5G, 6G, Wi-Fi, satellite, LAN, or other and make interoperable thought Open APIs. Services for real-time, near-real-time and non-real-time data collection, monitoring, analyses could be stored and processed locally on a server or remotely. The resources could be shared at any level of the architecture and resource orchestration will be supported by the distributed operating systems. Digital twin/virtual reality models are presented on the right part of the platform architecture. The data collected by the sensors is continuously imported in the digital simulation models to allow further analyses of the events that could not be experimented easily in the real systems such as disasters, damages, risk analyses, predictions of failures and much more.

The IoT network is presented on the left part of Fig. 1. It has typical three layers necessary for the deployment, connection and collection of the data. There is a need for much more complex architecture when the devices and local area networks are not only locally connected but cover the entire cloud-to-edge continuum. This is the reason to have a mirror architecture in 5 layers on the right part of the figure. Coordination between the real and simulated networks are under intensive standardization. Real-time and non-real-time coordination is analyzed. There are also no rules on how to create the digital twins. Event-driven models (e.g., finite-state automata), chronological models, analytical models or combination of them could be implemented in different time scales. The analysis of the data is based on the independent/dependent samples of events and the law of large numbers. Other simulation technologies are also considered [31].

The simulated part is developed after a careful study of the nature of the model parameters. It implements different distributions for different types of events. Transitional and steady-state states of the digital twin model are analyzed to allow estimation of exceptional events such as congestion, overloads, lack of capacity, shortage in resources, probability of damage etc.

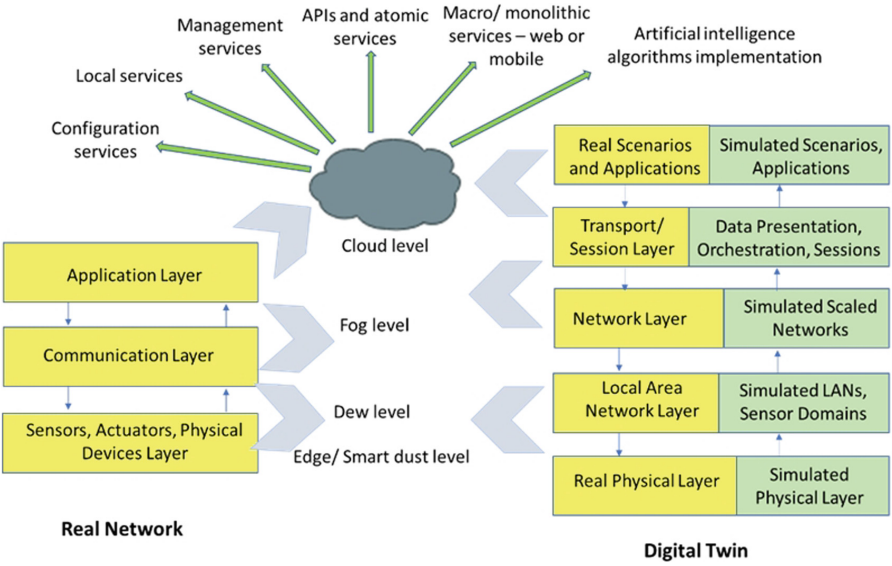

Fig. 1. INHABITAT IoT architecture [20, 29, 30]

The physical platform is considered in most cases distributed by nature. The digital twins could be centralized or distributed by implementing known cloud-to-fog-to-dew-to-edge computing technologies and intensive resource/data sharing. The implementation of machine learning algorithms at the edge/fog/cloud levels creates new opportunities for the creation of atomic and monolithic services, different APIs, managed services, and many other additional functions.

All models are expected to be reusable in different sectors and implementations. Digital twins are becoming an important place for investigation of events and education of the users and professionals. For example, end-users such as children and senior adults could be trained preventively on how to behave in cases of fire, floods or other disaster. The solutions will have a high social impact.

The technical part of the inspiring architecture does not separate mobile and fixed networking solutions. The systems are mixed and in conclusion build ad hoc at different scales. One possible way to collect data is presented in Fig. 2 where the IoT server could be situated at the edge or in the cloud as per design decision. The architecture shown in Fig. 1 is capable of integrating multiple IoT implementations and scale them. Security is considered at all layers of the architecture as well as the resilience and reliability of the platform.

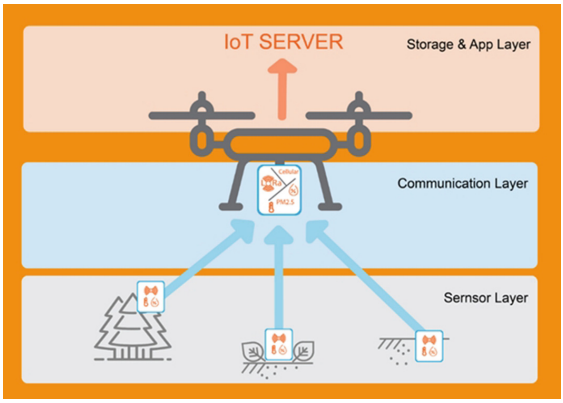

Fig. 2. Collection of data [20, 29, 30]

4 The Syllabus

When the syllabus was created, special attention was paid to the data structures and how the data is spread and processed in the cloud-to-edge continuum. For this reason, data visualization is an important part of the courses. Data visualization needs a high degree of customization and machine learning algorithms will support the process of specialized training of the data presentation models implemented in different environments and sectors.

The proposed MSc on Sustainability IoT Systems course includes (Tables 1 and 2):

- Two dedicated courses on Urban Innovation and Business Administration with additional focus on identifying business opportunities, cultivating commercial mindset, business logistics and financial planning, selling to customers and defining goals.
- Guidelines from the European Commission's "Entrepreneurial training and education for teachers - Guide for Educators"
- A chance to participate in a cross-border exchange programme and gain practical knowledge by working with the experienced entrepreneurs during the one month of practice and receive insights into business culture of another country and develop intercultural competence.
- The opportunity for the students to participate and exchange experiences in a course developed by partners across 10 EU countries (five academic institutions and seven enterprises) and network, via the e-Learning platform and in person, with people from a wide spectrum of backgrounds, professions, new markets, and potential business partners.
- The development of a demonstrator IoT system to address the rapid climatic changes that the sustainability industry is facing and explore new solutions in tackling this urgent issue.
- Dissemination actions towards sustainable IoT at partner countries addressing local and multinational communities interested in the future of smart sensing.

Table 1. Course Syllabus

No	Title	ECTS
1	Sustainable Development Policy, Law & Economics	4
2	Data Acquisition & Sensors	4
3	LabVIEW Training	4
4	Sustainable Networks and Supply Chains	4
5	Remote Sensing & Wireless Sensor Networks	4
6	Drone Systems	4
7	Climate Change and the Built Environment	4
8	IoT Platforms & Systems	4
9	Sustainable Urban Planning	4
10	Sustainable Industrial Engineering	4
11	Local Culture & Language - Italian	4
12	Recycling & e-Waste	4
13	Waste Water Treatment Systems	4
14	Smart Transport	4
15	Geodata Management Systems	4
16	Data processing & Blockchain	4
17	Renewable Energy	4
18	Green Buildings	4
19	Augmented/Virtual Reality	4
20	Urban Innovation & Entrepreneurship	4
21	Business Administration	4
22	Local Culture & Language - Lithuanian	4
23	Industrial Practice/ Developing Tool Demonstrator	12
24	Diploma Thesis	20

Table 2. Micro-certifications

No	Title	ECTS
1	Environmental Business Administration	4
2	Sustainable Development Policy, Law & Economics	4
3	Urban Innovation and Entrepreneurship	4
4	Data Acquisition & Sensors	4

(*continued*)

Table 2. (*continued*)

No	Title	ECTS
5	NI LabVIEW Training	4
6	Remote Sensing & Wireless Sensor Networks	4
7	IoT Platforms & Systems	4
8	Data processing & Blockchain	4
9	Augmented/Virtual Reality	4
10	Sustainable Networks and Supply Chains	4
11	Climate Change and the Built Environment	4
12	Sustainable Urban Planning	4
13	Sustainable Industrial Engineering	4
14	Geographic Information Systems	4
15	Recycling & e-Waste	4
16	Waste Water Treatment Systems	4
17	Smart Transport	4
18	Renewable Energy	4
19	Green Buildings	4

5 Results

The participating academic institutions all teach subjects related to Sustainability studies and IoT systems, but none offers a complete educational solution. They were selected because their curriculum and practical expertise differs from each other with minor overlapping but at the same time, when joined together under the INHABITAT umbrella, form a complete curriculum needed for the INHABITAT MSc course. The universities aim to foster long term cooperation and fortify their curriculum by joining this project (Fig. 3).

The hosting SMEs founded by entrepreneurs in the field of Smart Urban Solutions and as host entrepreneurs, are expected to benefit from fresh ideas coming from the participating students, as well as tapping into a "candidate pool" of potential new and skillful employees or that of potential new business partners. In addition, they expect to benefit by taking advantage of this cooperation and technological exchange to enhance their product's abilities and examine in common the market potential of the developed demonstrator system, set to confront the digital and green skills management challenges.

The results of the first-year experience are expected to include:

- 40 students
- 40 professionals in the certification program
- 40 EU grants for practical study
- 40 EU grants for the internship in the companies and diploma theses preparation
- Coordination and implementation of different instruments for education (Fig. 3)

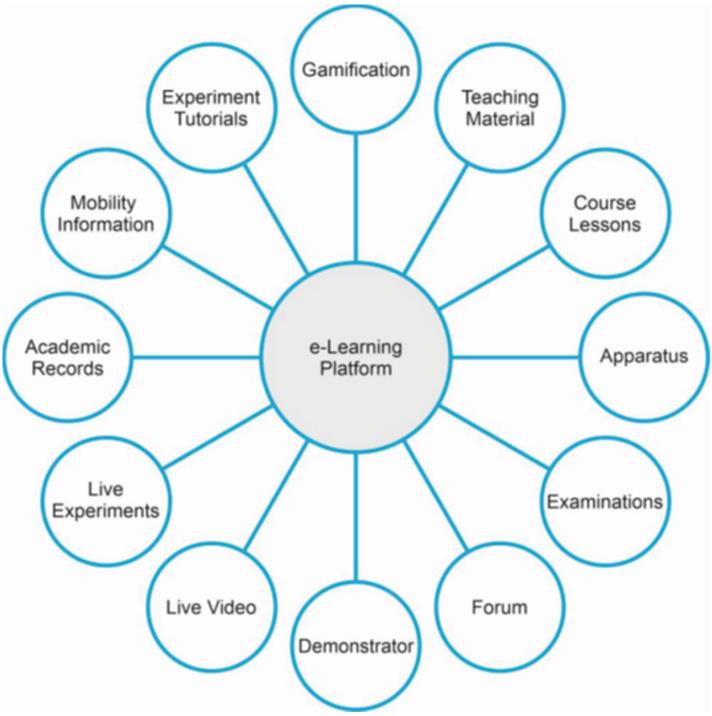

Fig. 3. Major e-Learning platform interactions

- Attraction of new SMEs to support project work
- Better employers' satisfaction
- Fast qualification
- Gained experience in accreditation
- Easy access to education and innovation
- Gain innovative education
- Increase in skills and employability
- International mobility
- Getting teachers and researchers and developers working together
- Expand interaction with local stakeholders
- Create spin-offs
- Create/support new businesses
- Increase European teaching and learning innovation
- Connect with regional industry and end-users
- Improve existing and develop new products
- Attract new clients
- Expand in new markets

Important outcomes for the consortium could be summarized as:

- Filling the void created by the sudden rise of the IoT systems request in the sustainability-related industries.
- Enhance transnational cooperation between academia and enterprises and design state-of-the-art learning tools that provide solutions to current market needs
- Increase integration of entrepreneurship to the students by creating interdisciplinary cross-border hands-on exchange courses where they can receive the necessary knowledge and tools to address the industry's needs and get competencies in developing an innovative project from concept to business plan.
- Design easily deployable syllabus for use by other EU educators
- Prepare new tools for the teachers based on the digital twins and with support of the industrial partners.

The idea is based on an analysis of the market as it stands today with realistic and well-defined objectives that focus on a topic highly relevant to the participating organizations and target groups. It is expected that this project will be the starting point for the realization of synergies between different fields of education, training, and youth, in line with the work of the partners.

The consortium is proposing a course that will bring added value to the EU with a setup that would not be possible to be carried out from one country.

6 Conclusions and Future Work Plans

In this paper we propose an innovative curriculum in the theme of Smart Urban related IoT systems that includes cross-sectoral interactive teaching methods and partnerships with major educational and industrial organizations.

The output of the partnership is a design of courses that gives additional skills to those interested in a career on Smart Urban Systems and allows the partners to create an ongoing MSc degree & micro-certificate that will last long.

The study program will be accredited by the Kaunas Technical University as a pilot academic institution. The idea is to break the bound and local legislation frames in different countries and to allow a worldwide, distant and in-site education for the benefit of the students. The diploma is recognized in every country of the European Union. The program is open and flexible to new companies and universities to join. The international team of educators ensures the sustainability of the solution.

The interdisciplinary approach towards the syllabus is highly in line with the European Commission′s aims in the vast implementation of the IoT solutions. Students will be educated in how to think about sustainability of living and how to implement professional solutions to achieve this goal. This is a significant step towards a green and circular economy.

The future work plans include the development of the courses and experimental proofing in 2025 and 2026.

Acknowledgments. This work is developed under the support of the project Intelligent Sustainable Habitats master's course, (INHABITAT), under the Call: ERASMUS-EDU-2021-PI-ALL-INNO — Partnerships for Innovation: Alliances, EU Grants: Application form (ERASMUS BB and LS Type II): V1.0 – 25.02.2021.

References

1. Masaracchia, A., Sharma, V., Canberk, B., Dobre, O.A., Duong, T.Q.: Digital twin for 6G: taxonomy, research challenges, and the road ahead. IEEE Open J. Commun. Soc. **3**, 2137–2150 (2022). https://doi.org/10.1109/OJCOMS.2022.3219015
2. Stixis: M2M IoT Sector Map. stixis.com/iot-m2m.php. Accessed 10 Jun 2024
3. Grand View Research: Environmental monitoring market size. grandviewresearch.com/industry-analysis/environmental-monitoring-market. Accessed 10 Jun 2024
4. McKinsey: unlocking the potential of the Internet of Things. mckinsey.com/business-functions/digital-mckinsey/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world. Accessed 10 Jun 2024
5. United Nations: Department of economic and social affairs. https://www.un.org/development/desa/ en/news/population/2018-revision-of-world-urbanization-prospects.html. Accessed 10 Jun 2024
6. Forbes: Investing in innovation: the rise of the smart city. https://www.forbes.com/sites/forbesfinancecouncil/2020/12/03/investing-in-innovation-the-rise-of-the-smart-city/?sh=38a90df95ba6. Accessed 10 Jun 2024
7. IEA: Renewables. iea.org/fuels-and-technologies/renewables. Accessed 10 Jun 2024
8. European Commission: Renewable energy directive. ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive/overview. Accessed 10 Jun 2024
9. Renewable energy magazine: how IoT is transforming the energy industry. Renewable energy magazine.com/emily-folk/how-iot-is-transforming-the-energy-industry-20190418. Accessed 10 Jun 2024
10. Ecole polytechnique masters programmes. https://www.findamasters.com/masters-degrees/course/master-of-science-and-technology-in-internet-of-things-innovation-and-management/?i1858d8517c62908. Accessed 10 Jun 2024
11. Newcastle university school of engineering. https://www.findamasters.com/masters-degrees/?Keywords=internet+of+things. Accessed 10 Jun 2024
12. United Nations University: the global e-waste monitor (2017). collections.unu.edu/eserv/UNU:6341/Global-E-waste_Monitor_2017__electronic_single_pages_.pdf. Accessed 10 Jun 2024
13. The World Bank: global waste to grow by 70 percent by 2050 unless urgent action is taken. worldbank.org/en/news/press-release/2018/09/20/global-waste-to-grow-by-70-percent-by-2050-unless-urgent-action-is-taken-world-bank-report. Accessed 10 Jun 2024
14. The fifth estate: Ewaste Let's make IoT sensors part of the solution not the problem. thefifthestate .com.au/waste/ewaste-lets-make-iot-sensors-part-of-the-solution-not-the-problem/. Accessed 10 Jun 2024
15. Horizon2020 Smart, Green and Integrated Transport. ec.europa.eu/programmes /horizon2020/en/h2020-section/smart-green-and-integrated-transport. Accessed 10 Jun 2024
16. European Union Industry 4.0 in agriculture: focus on IoT aspects. ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Agriculture%204.0%20IoT%20v1.pdf. Accessed 10 Jun 2024
17. European commission: environment and climate action. ec.europa.eu/programmes/horizon 2020/en/area /environment-climate-action. Accessed 10 Jun 2024
18. O*Net Online Job Descriptions, onetonline.org. Accessed 10 Jun 2024

19. Chebanyuk, O.: Software reuse approach based on review and analysis of reuse risks from projects uploaded to github. In: Zlateva, T., Tuparov, G. (eds.) EAI Computer Science and Education in Computer Science. EAI CSECS 2023. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol. 514, pp. 144–155, Springer, Cham (2023). https://doi.org/10.1007/978-3-031-44668-9_11
20. UFO: emerging indUstries new value chains boosted by small Flying Objects (2022). https://eic.ec.europa.eu/news/ufo-emerging-industries-new-value-chains-boosted-small-flying-objects-2022-02-22. Accessed 10 Jun 2024
21. Berginsight: M2M/IoT applications in the agricultural industry. berginsight.com/ReportPDF/ProductSheet/bi-agriculture-ps.pdf. Accessed 10 Jun 2024
22. Business Wire: analysis on the $28.9 billion green technology and sustainability market. businesswire.com/news/home/20190924005777/en/Analysis-on-the-28.9-Billion-Green-Technology-Sustainability-Market-2019–2024---ResearchAndMarkets.com. Accessed 10 Jun 2024
23. European commission press release: EU leads the way with ambitious action for cleaner and safer seas. europa.eu/ rapid/press-release_MEMO-17–3588_en.htm. Accessed 10 Jun 2024
24. Internet of Things – MSc, University of the West of Scotland, master′s courses in computing. https://www.findamasters.com/masters-degrees/course/internet-of-things-msc/?i360d6745c52421. Accessed 10 Jun 2024
25. Msc networks and telecommunication, Internet Of Things (IOT) track. https://www.eurecom.fr/en/teaching/master-networks-and-telecommunication/msc-networks-and-telecommunication-internet-things, https://www.findamasters.com/masters-degrees/course/internet-of-things-iot-msc/?i2722d7864c51692. Accessed 10 Jun 2024
26. Embedded systems and Internet of Things (ES-IoT) MSc, newcastle university school of engineering. https://www.findamasters.com/masters-degrees/?Keywords=internet+of+things. Accessed 10 Jun 2024
27. Master of science and technology in Internet of Things: innovation and management ecole polytechnique masters programmes. https://www.findamasters.com/masters-degrees/course/master-of-science-and-technology-in-internet-of-things-innovation-and-management/?i1858d8517c62908. Accessed 10 Jun 2024
28. Master in Internet of Things, online nuclio digital school masters opportunities. https://www.findamasters.com/masters-degrees/course/master-in-internet-of-things/?i3627d8822c70125. MSc urban digital transformation & innovation: governance and economics of cities, erasmus university rotterdam institute for housing and urban development studies. https://www.findamasters.com/masters-degrees/course/msc-urban-digital-transformation-and-innovation-governance-and-economics-of-cities/?i78d6852c58005. Accessed 10 Jun 2024
29. Flying Forest Fires Fighting (4F) Project. https://comicon.bg/en/обекти/4f. Accessed 10 Jun 2024
30. Goleva, R., et al.: An approach to environmental study from observations and sensing towards a digital twin. In: Zlateva, T., Tuparov, G. (eds.) EAI Computer Science and Education in Computer Science. EAI CSECS 2023, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol. 514, pp. 247–262, Springer, Cham (2023). https://doi.org/10.1007/978-3-031-44668-9_20
31. Laskov, L.M., Marinov, M.L.: List of optimal solutions of the minimum cost for minimum time assignment problem. In: Zlateva, T., Tuparov, G. (eds.) EAI Computer Science and Education in Computer Science. EAI CSECS 2023, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol. 514, pp. 87–101, Springer, Cham (2023). https://doi.org/10.1007/978-3-031-44668-9_7