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A MULTIDISCIPLINARY TRAINING PROGRAM FOR SMART CITIES TECHNICIANS AND ENGINEERS

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Abstract

A Smart City is a city where traditional infrastructures and services are made more efficient by exploiting digital solutions for the benefit of citizens and businesses. A Smart City aims to transform its infrastructure and services to offer smarter urban transport networks, upgraded water supply and waste disposal facilities, as well as more efficient ways to light and heat buildings. A Smart City also aims to have a more interactive and responsive city administration, safer public spaces, as well as to meet the needs of an ageing population. However, the lack of skills is a major barrier for the design and deployment of smart solutions for sustainable cities and thus to exploit the Smart Cities potential. In this work, we present a curriculum for the upskilling and reskilling of Smart Cities Technicians and Engineers. The curriculum adopts a student-centered and multi-disciplinary approach combining an adaptive blend of technical skills and competences for Smart Cities enabling technologies, as well as non-technical (soft, entrepreneurship and green) skills and competences. Moreover, the curriculum is modular and flexible, including a set of courses that are further split into training modules and sub-modules. The curriculum has been developed in the context of the Erasmus+ project SMACITE and will be supported by key stakeholder groups including SMEs and other labor partners, education and training providers, the public sector and last but not least, learners themselves.

Keywords: *Smart Cities, education & training, curriculum, MOOC, Virtual Worlds, ESCO job profiles, SC Technician, SC Engineer.*

1. Introduction

A Smart City is an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects. Research and Market says that the global market of Smart Cities is expected to grow from $511,6 billion in 2020 to $1.024,4 billion by 2027 with 14,9% compound annual growth rate. This growth is driven by the increasing demand for public safety, rising urban population, and growing government initiatives. Smart Cities contribute to the EU objectives towards social fairness and prosperity, empowerment of people through digital technologies, as well as the objectives of the European Green Deal.

Smart cities utilize data and deploy services using advanced technologies, such as Cloud Computing, Artificial Intelligence, and Internet of Things to enhance existing services and offer new, as well as, to provide context-aware views on city operations. Their development is highly complex and challenging and requires technicians and engineers from the public sector and industry equipped with skills and competences that are currently in short supply. Thus, given the dynamic nature of Smart Cities, their workforce needs to be reskilled/upskilled by acquiring new and transferable skills and knowledge.

The lack of **digital skills** is the biggest barrier towards effectively deploying big data and other digital technologies for city management. According to a recent survey of 3.000 tech leaders, conducted by KPMG and IT outsourcers Harvey Nash, 65% of the responding companies declared challenges to hire professionals with data and analytics skills (Harvey Nash & KPMG, 2020). Another survey also showed that 76% of companies felt like they needed more higher-level Internet of Things specialists (Forbes, 2019). Moreover, the public sector's digital skills shortages put brakes on its digital transformation with 40% of public sector organizations not having the right digital skills in place.

Helping the Smart City face its economic, environmental, and social challenges also requires a continuous update of knowledge and skills that go far beyond the technical field and cover a wide range of non-technical/transversal areas. There is need for Smart Cities technicians and engineers equipped with

soft skills, like critical thinking/problem solving, communication, and leadership. Such skills are also in short supply with Cedefop emphasizing the need for a better match between education and training and what industry requires in the field of personal competences. Moreover, to seize the entrepreneurial opportunities generated by the infusion of technology into the urban space, the development of **entrepreneurial skills** is essential. Last but not least, developing **green skills** to meet the needs of the transition into a carbon-neutral and circular economy and design effective ways of tackling urban development issues (e.g. air pollution, congestion, sustainable living) is another challenge that the Smart Cities technicians and engineers are facing.

2. Problem and our contribution

Although there exist education and training programs on cutting-edge digital technologies (e.g. Artificial Intelligence, Internet of Things, Big Data) both at higher education and vocational education and training, **there is lack of education and training programs** specialized in the domain of **Smart Cities** that combine an adaptive blend of both **technical and non-technical skills and competences,** which are essential for the professionals designing, deploying and operating sustainable Smart Cities. Education and training providers, as well as the industry, research organizations and the public sector, need to address the skills gap in the Smart Cities domain, by cooperatively designing high quality, attractive and flexible curricula using well-known EU standards and frameworks.

We hereby present a training program for Smart Cities Technicians and Engineers that has been designed in the context of the Erasmus+ project "SMACITE - Boosting the technical and non-technical skills and competences of Smart Cities technicians and engineers" (https://smacite.eu/). The project aims to address the skills gap of Smart Cities technicians and engineers, by designing and testing a vocational education and training program that is based on a novel and multi-disciplinary curriculum combining digital skills on Smart Cities enabling technologies, with soft, entrepreneurship and green skills. The curriculum will be delivered using current technology-enabled learning tools: A MOOC for the technical competences and Virtual Worlds for the non-technical competences. The benefits of using VR technologies to teach non-technical competences have been proved to be numerous (PwC, 2020): (i) it is 4x faster to train using VR than in a traditional classroom, (ii) VR learners are 275% more confident to apply skills learned after training, (iii) VR learners are 3.75x more emotionally connected to content than classroom learners and (iv) VR learners are 4x more focused than their e-learning peers.

3. Related work

The curriculum is built on the results of past activities and projects carried out in the field of education and training at cutting-edge technologies (such as Big Data and IoT), competences development and Smart Cities training. The most relevant projects are the following:

a) **DevOps competences for Smart Cities** (Smart-DevOps, 2023): the project addresses the gap between today and future skills demands of municipal workforce by emphasizing on the exploitation of the DevOps emerging employment paradigms. Smart-DevOps identifies competences and corresponding job role profiles by resulting into DevOps modular VET curricula based on adult learning outcomes and lifelong training principles.

b) **MSc in Smart Cities and Communities** (SMACCs, 2023). The program is designed to educate the next generation of engineers and researchers in Smart Cities by teaching best practices from 4 of Europe's most prestigious universities and by fostering collaboration with industry through research.

c) **Innovative Approach Towards a Master Program on Smart Cities Technologies** (SMARTCITY, 2023). The project aims to create a new breed of multidisciplinary ICT engineers in Smart City technologies by harmonizing Kazakhstan, Mongolian and Russian education with the EU.

There are also some recent research activities at the domain of Smart Cities training. (Kaufmann et al, 2020) address the shortage of both, digital and transferrable skills that are needed for the various Smart Cities' sectors differentiated by more strategic roles of Smart City Planner and Chief Digital Officer, as well as the more operational IT Officer. (Adiego and Martín-Cruz, 2021) aim to explain the development of an online training curriculum to enable students to acquire the transversal competences needed to work on smart cities projects. In this curriculum, a modern approach to the teaching-learning process was applied, suitable for the interdisciplinary and multinational learning challenges that Smart Cities impose, but within the framework of a university-industry European partnership. Finally, (Fitsilis and Kokkinaki, 2021) present the results of the SmartDevOps project, which attempts to systematically define the required smart cities competences and to outline the curricula that can be used for the development of the required knowledge coherently and systematically.

SMACITE complements the aforementioned efforts by a) proposing 2 emerging Smart Cities job profiles for ESCO, b) developing a novel Smart Cities curriculum and a diagnostic tool for identifying personalized learning pathways and c) developing a MOOC and Virtual Worlds tailor-made to cover the training needs of Smart Cities technicians and engineers.

4. Curriculum

4.1. Methodology for curriculum development

The methodology adopted for the design of the SMACITE curriculum is based on the ADDIE model (Peterson, 2003). It is a flexible, systematic process used by instructional designers and training developers to break down the training development process into actionable steps and create effective learning experiences. The ADDIE model consists of 5 steps (analyze, design, develop, implement, and evaluate) that are described below together with their application in SMACITE curriculum.

The **analysis phase** is focused on the target audience and can be considered as the goal-setting phase. At this phase, a needs analysis was conducted to determine the requirements of the target audience, as well as standards and competencies to establish a foundation when determining what students need by the completion of the curriculum/training. The **design phase** translates all the information derived from the analysis phase into a learning design. At this phase we have defined for each course of the curriculum its aims, learning outcomes, modules and duration. For each of the two job profiles identified in the project, i.e. Smart Cities Technician and Smart Cities Engineer, and for each course of the curriculum, we designed a different set of learning outcomes, based on the description of the 2 profiles (including their functions aligned with ESCO and (essential and optional) knowledge and skills), as identified at a previous stage of the project (Pospelova et. all, 2023). The **development phase** is about the development of the training material and required technology for the delivery of the curriculum based on the design done at the previous phase. The main questions addressed at this phase are the following: How the training material will be delivered? Which is the format of the training material? How the quality of the training material will be evaluated? The **implementation phase** is about the delivery of the training. Key elements include communication with participants, collection, and running a train-the-trainers program for the roll-out of the piloting of the curriculum. Finally, the **evaluation phase** aims to evaluate whether the goals identified in the analysis phase were achieved. Common questions that should be addressed at this phase are the following: Did the learners learn what we wanted them to learn? Were they able to apply new skills? Were they motivated to learn?

The main resources we considered for curriculum design are among others, a) the guidelines for developing ICT Professional Curricula as scoped by EN16234-1 (e-CF) (European Committee for Standardization, 2022) and b) the CEDEFOP report for defining, writing and applying learning outcomes (CEDEFOP, 2017). The main challenges we faced for the design of the curriculum was the definition of different learning outcomes for the Smart Cities Technician and Smart Cities Engineer profile and their connection with the different modules of each course with the aim of providing personalized learning pathways.

4.2. Curriculum description

The SMACITE curriculum implies a shift from a narrow perspective, viewing the curriculum as a list of subjects to be taught, towards a broader perspective, characterizing it as the overall learning experience of individuals (and groups) not only in schools, but throughout their professional lives.

The key characteristics of the SMACITE curriculum are 3: **multidisciplinary**, **modular** and **flexible**. The curriculum combines an adaptive blend of technical courses for Smart Cities enabling technologies (e.g. cloud computing and IoT) and non-technical courses for building the soft, entrepreneurship and green skills and competences of Smart Cities Technicians and Engineers. More specifically, the curriculum addresses soft skills for Smart Cities technicians and engineers through a set of training modules, such as Interpersonal Communication, Critical Thinking and Problem Solving, Leadership and Management and Managing Through Change. It also integrates entrepreneurial skills, such as Project management, Entrepreneurship and Innovation to stimulate a sense of initiative and entrepreneurial attitudes, mind-sets, and skills in learners. Last but not least, it integrates green skills, such as Energy Conservation and Waste Management, that are linked to the transition to a circular and greener economy.

Thus, in addition to building the technical skills of the target profiles, the curriculum aims to stimulate a sense of initiative and entrepreneurial attitudes and mind-sets, as well as to foster social responsibility. This is in line with the "Smart cities and infrastructure" report of the Economic and Social Council of the United Nations that concludes that "*there is a need for curriculum reforms and promote multi-disciplinary learning at vocational education and training, in order to integrate the special skills requirements of smart infrastructure*" (United Nations, Economic and Social Council, 2016). Finally,

each course is divided into training modules allowing students to build their own personalized learning pathways based on their needs and the outcomes of a diagnostic tool which aims to promote student-centered learning. The curriculum gives emphasis on what an individual should know, understand and/or be able to do at the end of a learning process. Such curricula consist of an effective way to avoid potential mismatches between academia and industry, and furthermore to promote active learning and inclusive training. Moreover, it promotes problem-based learning, technology-enabled learning, as well as experience-based learning.

Table 1 provides an overview of the SMACITE curriculum. The curriculum includes 13 courses. 10 of them deal with technical knowledge and skills on Smart Cities enabling technologies that are applicable in different use cases, such as waste management, water management, energy management, traffic management and urban transportation. The rest 3 courses of the curriculum are focused on non-technical knowledge and skills for building the soft, entrepreneurship and green competencies of the learners. The total duration of the curriculum is estimated to 463 hours including self-study.

Table 1. Overview of SMACITE curriculum

	Course	**Estimated effort in hours**
Technical courses	Smart Cities	40
	Internet of Things	44
	Cybersecurity	50
	Cloud Computing	40
	Data Analytics and Visualizations	40
	Machine Learning with Big Data	40
	3D Printing	28
	Blockchain	28
	Drones	24
	Autonomous Vehicles	24
Non-technical courses	Soft skills	40
	Entrepreneurship skills	40
	Green skills	25
Total duration		463

The description of each course includes the following elements:

- The course summary and duration.
- The course objectives indicating its general direction or orientation in terms of its content.
- The learning outcomes for each of the identified job profiles.
- The teaching and learning methods to deliver the course.
- The assessment methods to evaluate the performance of the students.
- The recommended textbook(s).
- The outline of the course that includes the different modules, the target Smart Cities profile, the associated learning outcomes, the week(s) for the delivery of each module and the estimated effort in hours.

5. What is next?

The next steps include the development of the learning resources of the curriculum for the upskilling/reskilling of Smart Cities technicians and engineers. The learning resources will be short, relevant, contextualized and run both on desktops and mobile devices, meeting the need for micro-learning. The learning resources will cover different learning needs: learning resources for self-study (e.g. texts, short videos, and presentations), evaluation quizzes for learners to test their knowledge, and real-life projects/case studies to promote problem solving and skills building.

As a next step, we also plan to develop a diagnostic tool to identify the training needs of each learner and promote personalized learning pathways through the curriculum. The diagnostic tool will be designed based on the Smart Cities competences map developed at an earlier stage of the project. Furthermore, we will develop the MOOC for Smart Cities enabling technologies, as well as the Virtual Worlds for the online training of Smart Cities technicians and engineers aiming to build their soft, entrepreneurial and green skills.

The curriculum will be tested during 4 national pilots that will run in Greece, Bulgaria, Spain, and Italy. Prior to the beginning of the pilots, a “Train-the-Trainers” event will run, and a Trainer Handbook will be developed to support the trainers. The aim of the pilots is two-fold: on one hand to

ensure that the curriculum meets the needs and expectations of the key end-users (i.e. learners and education and training providers) and on the other, to evaluate the effectiveness of its different components (e.g. learning resources and learning tools). The main findings of the pilots will be used to make fine-tuning adjustments to the curriculum, learning resources and online learning tools.

6. Conclusions

We present a multidisciplinary, modular and flexible learning outcomes-oriented VET curriculum for the emerging job profiles of Smart Cities Technicians and Engineers. The curriculum combines technical and non-technical skills and competences and will be delivered using online learning tools (MOOC and Virtual Worlds). As curriculum development is a dynamic process that involves all relevant stakeholders (e.g. education and training providers, trainers and learners) the curriculum will be tested and evaluated in order to ensure that it meets the expectations of the target audience before being finalized at the end of the SMACITE project.

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