Smart Cities Education as Mobility, Energy & ICT Hub

Darya Bululukova[1], Momir Tabakovic[2] and Harald Wahl[1]

[1]*Institute of Information Engineering and Security, University of Applied Sciences Technikum Wien,*
Hoechstaedtplatz 6, 1200 Vienna, Austria
[2]*Institute of Renewable Energy, University of Applied Sciences Technikum Wien,*
Hoechstaedtplatz 6, 1200 Vienna, austria

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Abstract: The subject of smart cities is highly discussed topic not only in the domain-specific mobility, energy and ICT circles but also in the educational and research-related fields. The questions are arising along with the broader acceptance of smart cities by general public. What are the required crucial competence fields for future smart cities specialists? Are the existing study programs able to cover demand for smart cities education? What are the career prospects for future smart cities specialists? The European Academic Smart Cities Network is aiming to build up competence in the area of smart cities education, to establish an academic network in Austria and to expand the training opportunities at the University of Applied Sciences Technikum Wien with smart cities tailored Bachelor and Master study programs. This paper summarizes the status quo of the project activities and describes exemplary integration of the proposed educational programs based on practice- and professional field-oriented, diversity-fair approach. Starting with the relevant smart cities national strategies, the project proposes cross-departmental integration of smart cities into existing activities. The proposed approach may serve as a base for further development of smart cities specific educational opportunities at university level. Finally, a conclusion of the paper is presented in section 5.

1   CURRENT SMART CITIES TRENDS

To maintain urban high quality of living against the background of restricting conditions, it is necessary to strive for constant self-analysis and the development of new and innovative solutions.

Cities in Austria are constantly evolving and need to reinvent themselves continuously, especially due to drastically changing climate and increasing scarce of resources. This fact calls for novel global approaches. Since the end of 2010, the Austrian Climate and Energy Fund and the Federal Ministry of Transport, Innovation and Technology (BMVIT) have supported the development of strategies, technologies, and solutions to support cities and their residents in their transition to an energy-efficient and climate-friendly way of life. Common objectives of these strategies are the improvement of the quality of life and the positioning of Austria as an attractive business location.

While since 2010 the Smart City initiative has been focusing on the support of comprehensive urban demonstration and implementation projects in their calls for proposals, the BMVIT's technology program "City of the Future" is striving for the development of new technologies, subsystems and urban services in the modern cities (Climate and Energy Fund, 2011). Furthermore, in 2014, the City of Vienna has launched an extensive the Smart City Wien framework strategy (Stadt Wien, Magistratabteilung 18 - Stadtentwicklung und Stadtplanung , 2014).

The considered time horizons have been extended to 2050, since the necessary and often fundamental changes in the fields of energy, mobility or construction require cost and time consuming processes. The goals of the framework have been specified in a long procedure with several executive policy groups, as well as numerous experts. Apart from the national evaluation an intense exchange of experience has taken place with other European cities that likewise aspire to meet smart city goals.

The Smart City Wien framework strategy is

directed at diverse target groups of the city, including Vienna's citizens, enterprises, non-profit institutions, and, finally, the public sector itself. The strategy and derived actions are expected to deploy a strong external effect to position Vienna as a responsible and impulse-generating metropolis in Europe. (Stadt Wien, Magistratabteilung 18 - Stadtentwicklung und Stadtplanung , 2014).

2 EU-ASCIN GOALS

The European Academic Smart Cities Network (EU-ASCIN) project, founded by the municipal government of the City of Vienna, is an initial attempt to integrate smart cities topic into educational programs at the University of Applied Sciences (UAS) Technikum Wien. Furthermore, the project supports the existing Smart City Wien framework strategy in education and training fields of action. Along with the technology-oriented goals Smart City Wien framework defines equal opportunities in education, lifelong learning and social awareness as the crucial basis for the successful smart cities integration (Stadt Wien, Magistratabteilung 18 - Stadtentwicklung und Stadtplanung , 2014).

EU-ASCIN project provides a solid foundation for smart cities deployment through setting up of the academic network, enhancement of the existing study programs with the smart cities emphasis and design of the new study programs.

The implementation of the project goals takes place in three interacting tracks, addressing independent target groups, see figure 1.
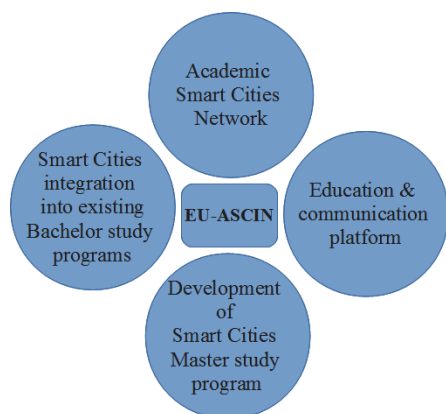

Figure 1: EU-ASCIN goals.

The broader public is addressed by education and communication platform, providing open source courses in smart cities related topics, as well as

information on current events and citizen participation possibilities. Qualified decision makers are planned to be addressed by an international post-graduate program. Finally prospective smart cities specialists are addressed by currently developed Bachelor's and Master's programs (Bululukova and Wahl, 2015).

3 EU-ASCIN RESULTS

The previous research and planning of the EU-ASCIN project provided an extensive base for the follow up implementation steps (Bululukova and Wahl, 2015).

Hereinafter, a status update for the EU-ASCIN activities, as well the most significant project insights are described. The main achievements within project are the summer school, held in summer 2015, smart cities specialization integrated within the existing Bachelor study programs and the smart cities Master program currently being elaborated.

All activities within the project are accompanied by the gender and diversity screening. The development of the study program is based on the occupational research performed to specify the professional focus of the master program.

3.1 EU-ASCIN Summer School

The international exchange of knowledge is an important part of the EU-ASCIN project. Several summer schools have been already held in cooperation with the UAS Ulm, Slovak Technical University Bratislava, Széchenyi István University, Obuda University, and Budapest University of Technology and Economics in different smart cities related areas (Danube Universities, 2013). The 4th summer school Green Waves with an emphasis on smart cities along the Danube was held in June 2015. The initial session for this summer school was held in Vienna at the UAS Technikum Wien, presenting the smart city Vienna framework strategy, followed by a podium discussion with representatives from industry, government and academia. Afterwards, participants got the possibility to visit Urban Lakeside Aspern smart city project.

Vienna's Urban Lakeside, is Austria's largest construction site and urban development project with over 20 departments of the Vienna city administration involved. The development of the Urban Lakeside is more than the urban city planning

project, but rather building city within a city with the main goal to transform Aspern into an urban centre with international profile. The construction takes place in several phases over the next 20 years on the area equivalent to 340 football pitches, providing high-quality living environment for 20,000 people and same number of workplaces. The main goals of the project involve flagship activities for further urban development, implementation of outstanding building performance according to the EU directive on energy efficiency and use of energy-producing renewable energy technologies. (Aspern Development AG, 2015).

The second day Bachelor and Master students got the possibility to present their research and project results to all attendees followed by laboratory visit of UAS Technikum Wien.

Finally, an excursion to Gyor has been organised, for on-site visit of smart city related developments. The trip continued by visits of the TU-Budapest and Obuda University. Firstly, smart city activities in Hungary and the smart city related research from the participants was presented. The summer school was concluded with an on-site visit of energy-efficiency projects in Obuda residential area and intelligent lighting pilot test site.

On one hand, the summer school offered students great opportunity to gain insight into smart cities activities on international level. On the other hand, it is a big opportunity for students to benchmark their projects and knowledge in an international context.

3.2 Integration into Existing Bachelor Programs

The starting point to raise awareness of smart cities topic at the UAS Technikum Wien is the extension of the existing related Bachelor study programs. Students have the possibility to get acquainted with the general smart cities topics to be able to choose related Master courses. This chapter sums up the accomplished integration of smart cities subject into the Bachelor degree programs "Transport and Environment" as well as "Urban Renewable Energy Technology" at the UAS Technikum Wien.

The concept of the smart cities integration is intentionally focused three smart cities domains: smart mobility, smart energy, and ICT, with the goal to more deeply understand the interconnection of these areas. Individual domains have been analysed and specified within the initial research steps of the EU-ASCIN project (Bululukova, et al., 2014).

3.2.1 Smart Cities in Transport & Environment

The integration of the smart cities topics into existing Transport and Environment Bachelor Program is implemented as a one of 4 selectable specializations, which include Smart Cities, Intelligent Transport Systems, Electric Vehicles and Transportation Planning. While the other three specializations are covering more transportation domain specific topics, smart cities specialization is the first attempt to provide interconnected training courses, see table 1.

The specialization has been elaborated considering the requirements of Smart City Wien Framework Strategy goals and the observed educational gap in the interdisciplinary education (Wahl, et al., 2014).

Table 1: Bachelor specialisation courses.

Specialization Courses	Learning Outcomes
Socio-Technical Aspects of Smart Cities (3 ECTS)	Students are able to point out impacts and benefits of technological solutions considering gender and diversity aspects within crossover of mobility, energy and ICT in smart cities
Smart City Influencing Factors (3 ECTS)	Students are able to describe smart cities as a concept, to compare different implementations of smart cities in an international context and to define the interactions between urban planning, mobility, building, industry and energy planning
Big Data in Smart Cities (3 ECTS)	Students are able to analyse and explain challenges posed by Big Data, its sources and its potential impact for specific domain of smart cities and to make use of suitable tools for basic Big Data tools and frameworks
Urban Energy Supply Systems (3 ECTS)	Students are able to define influencing factors on the urban energy demand, to compare energy systems used in urban environments and to work with modelling and scenario-development tools

3.2.2 Smart Cities in Urban Renewable Energy Technologies

The Urban Renewable Energy Technologies

Bachelor's degree program is the interface between energy technology, technical building systems, and plant construction. Within the 4th or 5th semester of the program, three specialization tracks Building Energy Design, Large-Scale Plants and Integrated Energy Technologies are already offered. Starting in 2015, a new Smart Cities specialization track has been introduced.

The specialization starts in the 4th semester with such topics as integrated design of urban technological energy projects (energy, buildings, networks), design options (architecture in urban areas) and the user behaviour (diversity). The specialization of the 5th semester provides more complex insight into technological concepts, geographical aspects area and regional, urban administrative frameworks. The course is designed as hands on project work with the main goal to introduce an integrated planning process for a small smart city projects, for instance a building refurbishment in urban areas. The project implementation involves usage of specific simulation software. The project gains additional benefits through the integration of interdisciplinary teams. This course rated with 15 ECTS points for both semesters (6 ECTS in 4th and 9 ECTS in 5th semester).

3.3 Development of a Smart Cities Master Program

The main step planned for smart cities dissemination at the UAS Technikum is the elaboration of an inherent smart cities Master's degree program. Prior to development of the explicit curriculum, a feasibility study for education demand and skills analysis has been performed. The demand analysis considers future employment prospects of the graduates based on relevant studies and secondary statistical data analysis. Additionally, the study includes interviews with fifteen experts from the smart cities relevant companies and organizations.

Furthermore, the acceptance analysis evaluated several study programs with certain degree of coherence to the planned Master's degree program, to estimate the number of future potential applicants.

The planned curriculum for the new program is strongly compliant with the general educational strategy of the UAS Technikum Wien, which is divided into three main areas of expertise: technical, economic and social skills education.

The technical skills within the new Master curriculum are subdivided, on one hand into introductory compensation modules for students

with few to no smart cities background and on the other hand mandatory or selectable smart cities specific skills. To improve the interdisciplinary approach, the master program offers student the possibility to deepen their knowledge in hands-on project work. The economic and social skills courses are supporting the implementation, innovation with national and international trends and business models.

The general curriculum is built up as follows, see table 2.

Table 2: Master's degree program curriculum.

Areas of expertise	ECTS
Smart Cities related project work	12
Scientific Methodology and Tools	36
Smart Cities Domain Basics (introductory courses)	6
Smart Cities Core Competences	48
Socio-technical Skills	12
Economic, Management and Legal Foundations	6

Since the main goal of the master study program is to diversify student groups, it is important to guarantee equal chances for students with various backgrounds by providing introductory courses in the main topics of smart cities. The smart cities domain basics include the core areas, such as transportation planning, urban energy supply, IT networks, and data management fundamentals.

The mandatory courses such as urban mobility, smart cities frameworks, urban renewable energy systems, urban planning, data analysis, statistics, and business models, provide a very broad and interconnected insight into smart cities specific domains and introduce necessary tools for future smart cities specialists as decision makers.

Apart from the mandatory courses, students get the possibility to choose one specific elective track each semester. Currently, selectable topics cover extensive areas of smart cities, see table 3, to be extended for future needs.

Table 3: Selectable tracks in Master's degree program.

Selectable Track	Contents
Urban Housing	Densification in urban areas, energy-based renovation
Trends in urban energy supply	Technological trends in the energy supply of modern cities
Physical Measurement-Methods	Measurement technology of physical smart cities characteristics
Embedded Systems	Internet of things, sensor data

Table 3: Selectable tracks in Master's degree program (Cont.).

Selectable Track	Contents
Human factors in modern transportation	The human factors and transportation safety
Greenhouse emission reduction	Methods and concepts for reduction of the CHG
Urban logistic systems	Technology in urban logistics and fleet management
Electric vehicles	State of the art in battery technology and electric vehicles
Sensors and Control Theory	Sensor data measurement and usage in control theory, control engineering technology
Distributed and dependable systems	Sensor networks and distributed computing
Urban lighting technology	Lightning technologies for urban lighting
Image-processing	Applied image processing
IT Security in Energy and Mobility	IT security concepts in energy and mobility domains
eHealth	Integration and usage of connected medical IT infrastructures, crowed-sources healthcare
Big Data	Technical concepts in Big Data, semantic knowledge and linked data
Autonomous Driving	Technology for autonomous vehicles and navigation
Cooperative Systems	Car to car, car to infrastructure communication

Currently, the designed smart cities master program is in process of approval executed by a government-assigned quality assurance company.

3.4 Occupation Research

An important integrative part of the EU-ASCIN project is the professional field research of the smart cities. Internal and external specialists have been consulted, such as the City of Vienna endowed professorship for occupation research at the UAS Technikum Wien, as well as an external consultant agency. The main goal of this analysis is to clearly define the prospective job profiles.

The first step in the evaluation of the relevant competences includes clarification and delimitation of the concerned domains. The smart cities definition used in the EU-ASCIN project summarizes smart cities as development and implementation of IT-based and integrated city solutions with the main goal to achieve a sustainable urban development in the mobility and renewable energy domains.

As the results of the evaluation following main sectors for potential employment of the smart cities graduates could be identified:

1. Infrastructure, such as energy supply, transportation and logistics, ICT, environment and waste management
2. Management and planning, such as city administration and management, public safety, urban planning and building management
3. Industry, such as technology in mobility, energy and ICT domains
4. Services, such as R&D, education and consulting

Based on the identified employment sectors, the requirements on the educational program could be elaborated. The graduates of this master program are characterised by their ability to design and implement holistic city development projects, based on socio-technical constraints. This includes skills and competences in project and process management for development of urban infrastructures, social system analysis for cooperative and cross-domain support of urban stakeholders and technological assessment.

The design of the new smart city master program started with the definition of the required learning outcomes, and in particular what graduates are expected to be able to perform upon successful completion. In the area of smart cities professional skills students should be able:

- To assess and to manage urban traffic
- To design and asses energy-efficient supply infrastructures
- To design secure smart cities
- To integrate various data sources
- To elaborate holistic approaches for urban areas
- To implement cross-domain simulations and scenarios
- To develop new business models in cross-domain filed of mobility, energy and ICT

Apart from the technology specific knowledge and skills students must be able to perform tasks in the personal and social-technological field:

- To identify and analyse all affected user groups for urban solutions
- To cooperate and communicate with technical and non-technical diversified stakeholders
- To asses technological solutions in terms of

their social impact

The external research of the occupation demand has shown similar to the internal analysis results. Regarding the qualifications of the prospective graduates of the Master's program, the interviewed experts emphasized among other qualifications, the technical fundamentals in all areas of smart cities, but in particular in mobility, spatial and transportation planning, renewable energy, modern buildings and ICT. Furthermore the strong demand for competence in sociology, socio-demographics and policy frameworks has been identified.

The result of the external evaluation has assessed the employment situation for future graduates based on the quantitative surveys as very promising. The employment number in the relevant economic sectors, both in Austria an in Vienna in particular, have shown slightly increased shares in the past five years. The unemployment rates of the graduates in coherent UAS degree programs have shown comparably low numbers (Mertens and Schwenk, 2015).

3.5 Gender & Diversity

The European Commission convened an expert group "Innovation through Gender" in February 2011 (European Commission, 2013) to support dissemination of the gender topics in EU research.

In March 2013, the UAS Technikum Wien joined this initiative and defined Gender and Diversity guidelines for research and education. The guidelines, in particular, apply to the Smart City activities at the UAS Technikum Wien (UAS Technikum Wien, 2015).

At initial steps of the EU-ASCIN project all cooperation partners have been encouraged to participate in a gender and diversity workshop to discuss this topic in a smart city context. The project team itself shows a high diversity level in terms of language, culture and educational background.

The deliverables and the documents of the project are continuously screened according the Gender Mainstreaming Tool (GeM) developed at the UAS Technikum Wien. The GeM is composed of four steps: analysis, goal definition, realization and evaluation.

Within the framework of the project the educational course on socio-technical aspects of smart cities has been held for the first time in the Bachelor's degree Transport and Environment. The course was organized by the board member of Women in Mobility & Energy, Environment Network) (WIMEN) (WIMEN, 2015). WIMEN is an independent, non-political network of associates who use this forum for professional exchange in the field of their expertise. WIMEN focuses on the areas of mobility, energy, ecology and public space.

The eight students obtained an introduction to the topics of society and technology with special attention to gender and diversity issues.

3.6 Student Activities

The Smart City Wien Framework strategy has set the goal for steady reduction of resource consumption within the city boarders, the preservation of the quality of life and progress in the innovative field by 2050 (Stadt Wien, Magistratabteilung 18 - Stadtentwicklung und Stadtplanung , 2014). The area of resource conservation refers to the upgrading and rehabilitation of the urban housing. In the course of the smart cities specialisation, students got the possibility to take part in elaborating and design of an exemplary refurbishment project. The hands on project included development of a restructuring plan for renewable energy power supply, facade optimization, building automatization technology, quality of habitat and heating / cooling technology in connection with verification processes. The design was performed based on energy performance certificates and ecological balance sheets.

Students have been divided into four working groups, each dealing with the own independent tasks e.g. ventilation, heating, cooling, and daylight-use concepts. The second part of the project aimed to create two different heating and ventilation system options and to evaluate and review their efficiency. The work focused on the technical design and the energy efficiency assessment. The third part had the target to determine whether the restructuring was ecologically worthwhile, while ignoring the investment cost.

4 PROSPECTIVE COOPERATION AND ACTIVITIES

Since the EU-ASCIN Project has not been completed so far, several steps are still in progress, such as planned smart cities conference, ongoing development in smart cities competence teams, as well as, planned endowed professorship. This chapter sums up the activities and implementation steps planned within final project year.

4.1 Smart Cities Conference

In several past years, more and more conferences in the thematic section of smart cities have been organized. The aim of the most events is to bring together researchers, designers, developers, government, industry and practitioners interested in the advances and applications in the field of smart cities, green information and communication technologies, sustainability, energy aware systems and Technologies.

In contrast to the existing conferences, the EU-ASCIN smart city conference has the target to bring the academic community from Austria and Europe together. The two days lasting conference will be supported by City of Vienna and will take place at the Vienna City Hall in autumn 2016. The UAS Technikum Wien takes over the scientific leader of the conference.

The participating experts have background in infrastructure, urban planning, mobility, energy, socio-economic social implications, ICT, and usability. The conference will be completed by an on-site visit to the Aspern Vienna's Urban Lakeside.

4.1 Smart Cities Competence Team

Building up on the internationalization, networking, and know-how objectives of the EU-ASCIN project a subsequent activities for smart cities development has been planned and implemented.

On one hand, based on the long-term contact with the UAS Ulm (Germany) as well as existing network of Danube universities, a joint research activities followed by a joint smart city study program are currently being evaluated.

To be able to internally cover the increasing demand for smart cities specific courses an application for the own smart cities competence team has been submitted and successfully founded by the municipal government of the City of Vienna. The main objective of the competence team for Intelligent Technologies in Smart Cities (KiTSmart) is to develop smart cities related courses and support scientific dissemination in the research community (UAS Technikum Wien, 2016).

4.2 Endowed Professorship

The Energy Performance of Buildings Directive (EPBD) requires all new buildings to be nearly zero-energy by the end of 2020 (EPBD, 2014). Therefore, a fundamental re-orientation of teaching in the area of buildings and building blocks is required. UAS Technikum Wien is ready to meet this challenge and engages an endowed professorship exclusive for this topic. The aim is to implement new teaching methods for building and building blocks in the current Master's and Bachelor's degree programs.

Apart from the renewable power supply, the task of the endowed professorship is to develop competence within the area of building sustainability, i.e. usage of sustained materials, comfort, healthy and ecological buildings. In addition, the user's behaviour and diversity are the main focus, which is not yet integrated in daily building planning process.

5 CONCLUSIONS

The EU-ASCIN project proposes integration of the smart cities, taking into account requirements of the relevant regional and EU wide framework strategies, in particular, Smart City Vienna framework strategy. This paper sums up current status quo of the project with already accomplished milestones, including integration of smart cities into Bachelor's programs and development of an independent smart cities oriented Master's program.

Furthermore, the paper provides deeper insight into design process and motivation behind the development of the first smart cities specific practice-oriented education at UAS Technikum Wien. Detailed insights into occupation research, as well as gender and diversity sensitive topics are provided.

The proposed approach provides an extensive base for general design of modern study programs, which may be onward re-used, independent from the specific domain of smart cities. The experiences made within the project should offer more practical support for smart cities dissemination in academic and R&D fields.

ACKNOWLEDGEMENTS

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