Towards a Sustainable Smart Cities Integration in Teaching and Research

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Abstract: The urban population growth and rapid urbanization are the key issues many of the European cities are currently dealing with. Vienna, as the one of the leading cities, embodies the smart cities goals and values. The new Smart City Wien Framework Strategy is more than a technological approach, furthermore, it emphasises importance of the social innovation. Nevertheless, the strategy lacks concrete goals for academic research and smart cities integration into educational programs. Little to no academic research discusses smart cities oriented study programs. This paper aims to close existing gap and proposes exemplary practical approach to integrate smart cities concepts at the academic level. Starting with the basic evaluation of the existing smart cities relevant study programs in the European area, we elaborate three interacting tracks for implementation: educational Web platform, postgraduate program and cross-departmental study programs including student projects. A practical, professional field-oriented and diversity-fair approach is chosen. The paper describes the status quo of the implementation process and in particular a cross-departmental study program. This exemplary implementation concept of smart cities may serve as a basis for universities with practice-oriented education to utilize own smart cities related studies.

1 INTRODUCTION SMART CITIES FRAMEWORK

The smart cities concept is an emerging process with the key fields being often discussed among practitioners and academia. According to (Chourabi , et al., 2012), the concept of the smart cities can be divided into technological factors, human factors, and institutional factors as shown in Table 1.

Table 1: Smart cities factors (Chourabi , et al., 2012).

Technology factors	Human factors	Institutional factors
Physical infrastructure	Human infrastructure	Governance
Smart technologies	Social capital	Policy
Mobile technologies		Regulations and directives
Virtual technologies		
Digital networks		

One of the established classifications defines economy, people, mobility, environment, living, and governance as the main sub-areas of smart cities, with each sub-area characterized by several relevant factors (Giffinger, et al., 2014). Despite the smart cities concept often being emphasised as a systematic approach with all sub-areas equally involved into the goal achievement, the analysis by (Manville, et al., 2014) has shown that the smart cities initiatives are dominated by the smart environment characteristics. Over 50 percent of the initiatives in the examined sample included more or less smart environment-oriented activities. Table 2 sums up the number of cities with initiatives aligned with Europe 2020 goals. The lowest number of the initiatives was identified within the educational area.

The European framework strategy Europe 2020 defines a framework for the economical development across the region, in order to create smart, sustainable and inclusive economy (Manville, et al., 2014). The main targets include employment increase, R&D and innovation boost, climate change measures and education improvement. The intention in the educational area is to reduce the dropout rates

below 10 percent and to increase percentage of people, who completed at least the third level education, up to 40 percent (Manville, et al., 2014).

Table 2: Number of cities with Europe 2020 target oriented projects (Manville, et al., 2014).

Europe 2020 targets	Number of cities
Employment	4
R&D	2
Energy & Environment	18
Education	1
Poverty	7

This paper attempts to fill the gap in the area of smart people and education, by analysing the main goals within the existing smart cities initiatives and by purposing a practical integration plan.

The social and human factors within smart cities are specified by (Giffinger, et al., 2014) as follows:

- Level of qualification
- Lifelong learning
- Ethnic plurality
- Open-mindedness

The smart people definition implies e-skills, ICT-enabled working environment, free access to education and training acting in inclusive, creative and innovative society (Manville, et al., 2014).

1.1 Project Main Objectives

The Smart City Wien Framework Strategy of the municipal government of the city of Vienna emphasises inclusion of the different population groups, affordable quality of life, activation and participation of the citizens in decision-making processes and integration of the innovation into the social context, as the main prerequisites of a successful smart cities policy (Stadt Wien, Magistratabteilung 18 - Stadtentwicklung und Stadtplanung , 2014).

The main objectives of the framework till 2050 in the areas of mobility and energy include decrease of the overall energy consumption per capita in Vienna by 40 percent, increase of the renewable energy sources by at least 20 percent, reduction of the motorized individual traffic to 15 percent and complete switch to the alternative drive technology within the city limits (Stadt Wien, Magistratabteilung 18 - Stadtentwicklung und Stadtplanung , 2014).

In addition to the technology-oriented goals, the city of Vienna sees education and training as one of the main fields of action. Education as the basis of the smart cities should create equal opportunities.

The concept of the lifelong learning grants access to educational opportunities for all population groups.

The European Academic Smart Cities Network (EU-ASCIN) project, founded by the municipal government, supports the implementation of the Smart City Wien Framework Strategy through design of the new study programs and educational concepts, and through deployment of the smart cities concepts in the existing bachelor and master study programs at the University of Applied Sciences (UAS) Technikum Wien.

The current status quo includes first integration steps in the bachelor study programs "Transportation and Environment" and "Renewable Energy Technology".

1.2 Integration Plan

The dissemination of the smart cities concept takes place in three interacting tracks as displayed in Figure 1.
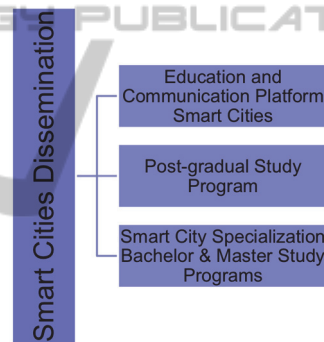

Figure 1: Three-track integration plan.

The first track addresses the broader public. On an own educational and communication platform, EU-ASCIN project provides up-to-date information in the area of smart cities, e.g. technological progress, relevant legislative regulations or current events. Apart from the information area, the platform provides required research infrastructure to simplify implementation of the innovative projects. Additionally, the platform supports academic institutions and industry stakeholder in finding cooperation partners for joint projects.

Second subarea faces qualified decision-makers as target audience. For the people who are already involved in the smart cities in their daily business and are willing to enhance their knowledge, EU-ASCIN plans to offer postgraduate study program with the required holistic know-how in this area. In the nearest future those professionals should provide broad range assistance in the smart cities

implementation.

Third subarea provides specializations within existing study programs for academic education with the main subject of smart cities. The UAS Technikum Wien already offers study programs involving some of the main topics, such as smart energy, smart environment, and smart mobility. In the context of the project, inter-departmental (mobility and energy departments) courses in smart cities are offered. EU-ASCIN has established cooperation with a partner university in Ulm (Germany) and Austrian Institute of Technology. Implemented Web platform will support study programs by providing e-learning courses.

2 RELATED STUDY PROGRAMS

In the first step, the evaluation of the existing smart cities related studies was performed. As a result, 15 Bachelor's and 24 Master's programs with such smart cities relevant focuses as renewable energy technologies, energy efficiency, building management, mobility and transportation, information and communication technologies, environmental studies and resource managements, electronics and driver assistance systems, telematics and control engineering could be identified at the universities of applied sciences in Austria. Additionally, 8 Bachelor's and 10 Master's degree programs at the universities in Austria are involved in some of the smart cities specific topics.

The considerable specific training opportunities exist on the European level, in form of European Master programs held on several partner universities. This reflects the core idea of connected interdisciplinary training. The European Institute of Innovation and Technology offers several Master's degree programs, such as Energy for Smart Cities, Energy Technologies and Smart Electrical Networks and Systems.

After analysing the different educational programs, few smart cities specific training opportunities, which implement smart cities as global, interdisciplinary topic could be identified.

From the evaluation results, the Master's degree program at the University of Applied Sciences Joanneum explicitly integrates the system approach into the Bachelor's degree study program "Energy, Transport and Environmental Management". At the university level the KTH Stockholm with Energy Innovation Master Program with smart cities specialization should be mentioned (Wahl, et al., 2014).

2.1 Mobility and Energy

The concept for the integration of holistic smart cities concept is based on the strong use of the synergies between its individual subareas. Previous concepts are strongly domain-specific approaches e.g. renewable energy oriented or mobility oriented study programs.

The proposed concept intentionally limits the scope of smart cities to the 3 chosen sub-aspects: smart mobility, smart energy and smart people (Wahl, et al., 2014). The advantage of this approach is the possibility for deeper understanding and the crosslinking of these areas.

Smart mobility is dealing with the energy-efficient, safe, comfortable and affordable transportation possibilities. Bachelor's degree program "Transportation and Environment" focuses on telematics, traffic management, traffic information systems, multimodal transportation modes, environmental aspects of the traffic engineering, electromobility, driver assistance systems, and traffic simulation (Bululukova, et al., 2014).

The student projects within the program include smartphone app development for traffic information, indoor navigation, multimodal ticketing, software development for traffic simulation, fleet management and container management, methodical analysis of traffic surveys, congestions and routing optimization.

Smart energy is a key concept of smart cities, which provides users with liveable, affordable, and environmentally friendly living space and supports their needs based on the sustainable energy technologies. The "Urban Renewable Energy Technologies" Bachelor's degree program offers a well-founded education with three topical focuses: renewable energy technologies, industrial-scale plants and buildings energy design. Students learn how to develop and set up the power supply systems of the future as well as how to dimension these systems and combine them into an integrated system (Bululukova, et al., 2014).

2.2 Professional Field Research

Design of the new study programs or specializations requires a clear definition of the prospective job profiles.

Austrian Institute of Technology (AIT) is involved into the smart cities research in several sub areas, such as integrated urban planning thermal energy networks, energy-efficient interactive

buildings and urban energy supplies. The broad field of action of AIT is beneficial for the evaluation of qualification requirements.

AIT has performed professional qualification requirements study in smart cities context. The crucial finding of the study points out the lacking of the interdisciplinary education and need for the system-integrator qualifications (Neumann and Schuetz, 2014).

3 SPECIALIZATION BACHELOR'S DEGREE PROGRAM

Based on the Smart City Wien Framework Strategy goals and the identified educational gap from (Wahl, et al., 2014) following four modules are currently integrated into the Bachelor's Degree Program within the Smart Cities specialization: socio-technical aspects of smart cities, influencing factors of smart cities, big data in smart cities and urban energy supply.

3.1 Socio-technical Aspects of Smart Cities

The specified module should raise the awareness for such concepts as gender & diversity and doing gender & diversity. The socio-technical aspects of smart cities are important components for the user needs evaluation. In the area of energy and transportation services, system planning and infrastructure design user needs are the driving decisive factor, defining service requirements and the user acceptance. The traditional survey and evaluation methods do not take into account different user groups and user needs. Current module provides up-to-date toolbox and emphasizes different interests.

3.2 Influencing Factors of Smart Cities

The main content of the module includes urbanisation and its influence on the climate, political strategies and frameworks, and cross-sectorial planning. The students are synchronized concerning the existing smart cities activities and gain knowledge in strategic decision-making.

3.3 Big Data in Smart Cities

The module is divided into the sub areas of data collection, data aggregation and processing, data mining, and data use for applications and services. The module provides practical technology oriented knowledge in interconnection of smart mobility, smart energy and ICT. Practical lab exercises utilizing state of the art technologies in the urban areas such as Dedicated Short Range Communication (DSRC), traffic surveillance cameras, inductive loops, and other traffic sensors support hands on learning.

3.4 Urban Energy Supply

The module provides knowledge in urban energy demand, energy systems in urban areas, interfaces in the energy infrastructure, and scenario development and modelling.

4 STUDENTS ACTIVITIES

4.1 Student Projects

Student projects should support the integration of the smart cities in the study plan. Existing Bachelor's study program already has an integrated project oriented learning part, specializing in mobility or energy applications. Those projects are usually initiated by students and supervised by professors in their own area of expertise. These projects fields are now expanded to include smart cities systematic approach and system integration problematic.

Proposed smart cities related projects might include:

- Quality of life sensor network (air quality, water quality, noise level, infrastructure availability, etc.)
- Reliable real time car to car communication
- Stereovision based car detection system
- E-cars charging interfaces
- Incentives systems for e-mobility
- Value added Web services based on the Open Government Data
- Digital radio based telematics services

Some of the already accomplished student projects are listed below:

- Mesoscopic traffic simulation based on the cellular automata, analysing mutual influence of the traffic participants
- Sensor-based free parking lot detection for the minimization of the pending traffic share in the total traffic volume

- Driver assistance app providing information concerning recommended speed for the 'green wave' time slots. The main goal of the project is the minimization of the acceleration and deceleration processes, and as a result, minimization of the fuel consumption and CO2 emissions.
- Sensor-based person detection in the public transport for occupation level calculation and seat availability detection. This service should provide information on the platform or bus stop attracting new user-groups to use public transport.

To encourage the systematic thinking approach and further development of the projects, the best practices projects summary is organized once a year. Both Bachelor's and Master's students are able to present the result of their work. By attending the review presentations younger students get involved into the recent activities and senior students become possibility to share their knowledge and get useful feedback.

4.2 Summer School

On the other hand additional extracurricular activities are offered for the students who want to deepen their knowledge beyond courses material. Several summer schools were organized together with UAS Ulm, Slovak Technical University Bratislava, Széchenyi István University, Obuda University and Budapest University of Technology and Economics (Danube Universities, 2013). During a one week program, participants were able to gain new experiences in courses with topics like photovoltaic systems, energy storage, power conversion, hybrid systems, intelligent transportation systems, solar energy, traffic simulation, etc.

A new summer school with the emphasis on smart cities will be held in summer 2015 with the already existing and established partner universities. Except for the smart cities specific courses and exercises, participants become the possibility to visit high tech research facilities, industry test sites and best practices living labs for smart cities.

5 CONCLUSIONS

The purposed integration of the smart cities in education takes into account the Europe 2020 targets, as well as supports regional Smart City

Vienna Framework Strategy in order to raise awareness and to achieve goals in the area of education. This paper sums up the implementation plan for the existing study programs, examining the future job profiles and smart cities initiatives goals. The next step may provide evaluation of the existing job requirements and requalification needs in smart cities related areas as a basis for the post gradual study program.

Furthermore, the proposed approach for the integration of the new topics into educational programs may be reused in applicable academic areas.

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REFERENCES

Bululukova, D., Wahl, H. & Ballner, M., 2014. European Academic Smart Cities Network – Renewable Urban Energy Systems, Sustainable Mobility and ICT Technology Nexus for Smart Cities Studies. In 2014, R.C., ed. *Proceedings Real Corp 2014*. Viena, 2014. -.

Chourabi , H. et al., 2012. Understanding Smart Cities: A integrative Framework. In *System Science (HICSS), 2012 45th Hawaii International Conference on System Sciences*., 2012. IEEE.

Danube Universities, 2013. *danubeuniversities.eu*. (Online) (01) Available at: http://danube universities.eu/ (Accessed 15 January 2015).

Giffinger, R., Kramar, H., Pichler-Milanovic, N. & Strohmayer, F., 2014. *Smart Cities Profiles*. Deliverable. Wien: - PLEEC Planning For Energy Efficient Cities.

Manville, C. et al., 2014. *Mapping Smart Cities in the EU*. Study. Brussels: Policy Department A: Economic and Scientific Policy European Parlament, Directorate-General for internal Policies.

Neumann, H.-M. & Schuetz, R., 2014. *Smart Cities Aktivitaeten des AIT*. Presentation. Vienna: - Austrian Institute of Technology.

Stadt Wien, Magistratabteilung 18 - Stadtentwicklung und Stadtplanung , 2014. *Smart City Wien - Rahmenstrategie*. Rahmenstrategie. Vienna: -.

Wahl, H. et al., 2014. *Smart Cities Aktivitaeten & Netzwerke: Identifikation von Schwerpunkten in Forschung und Lehre fuer das EU-ASCIN Projekt*. Deliverable. Vienna: - UAS Technikum Wien.