

Smart City – a Quest for Innovation within the EPS Framework

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1 ABSTRACT

The paper presents the process of education and its results which addressed the issue of innovation in the field of Smart City technology. The project was realised within the framework of a European Project Semester (EPS) at Lodz University of Technology. The Project Based Learning methodology enhances collaboration and creativity in finding solutions to defined problems. The first phase of the project was assigned to define germane areas of research under the general umbrella of Smart Cities. Further, brainstorming allowed students to choose a detailed task to be performed. The implementation phase entailed work on an application of their choice and its reality check in the urban environment of Lodz city centre. The students developed a smart phone application which may serve as a social platform allowing citizens to express their opinion on various spots in the city. The functionality is based on crowd-sourcing. The app structure is open and flexible and may be subsequently extended with the addition of new layers of information.

2 INTRODUCTION

Creativity as defined by Landry (2008,xxi) is an applied imagination using qualities such as intelligence, inventiveness, and learning along the way. Original ideas result from initial curiosity and innovation and after a little lateral thinking they require a more convergent approach that takes them through a reality checker from which an innovation might emerge. The new approaches to the training of engineers based on Project Based Learning methodology not only allow a more efficient and useful learning process but also provide an excellent framework for shaping innovative ideas.

The project discussed in the current paper was done as a part of the European Project Semester (EPS) curriculum at Lodz University of Technology, International Faculty of Engineering. The team of five young people (aged 20 to 22), coming from various European countries (Spain, France and Poland) and representing a wide range of fields of engineering (computer science, biomedical engineering, management), worked together in a strongly collaborative environment.

The project topic was delineated in a very general way and provided a broad range of themes under the common umbrella of Smart Cities. After extended research aiming at pinpointing the actual meaning of the term and reviewing all its aspects, the team was asked to propose their specific project which might answer a need. The presented approach, which was a result of a brainstorming process, allowed the identification of problems which were genuinely identical to those discussed in current presentations by leaders in the field. The project proposed as a result of the investigations was a smartphone application with the functionalities of a social platform for collecting citizens' opinion on various spots in the city. The application uses crowd-sourcing methodology to gather data on urban places, covering both commercial and public locations, such as: cafes and restaurants, squares and parks. Its functionality also allows the gathering of information on historical and natural heritage. A section will be left for people's opinion.

The paper is organised as follows: after this introduction, the EPS learning methodology is briefly presented, which points out the necessity for changes in engineers' education as well as discussing the main methodological assumptions. Section 4 explores the Smart City topic and the four main areas of research in order to justify the project's decisions. Further, the details of the proposed application are presented. The concluding part returns to the project and discusses possible developments of the tool.

3 EPS LEARNING METHODOLOGY

The European Project Semester is a programme offered at Lodz University of Technology (TUL), International Faculty of Engineering, to bachelor level students of various backgrounds who are in the third year of their studies as a minimum. It covers the whole semester workload (30ECTS) and is based on Project Based Learning (PBL) methodology. The method connects project organised or problem based learning and courses addressing design process organisation: Team Building and Project Management. It facilitates the acquisition of new skills and knowledge through an extended process of inquiry in response to a complex problem (Dym et al, 2005). The EPS gathers together students of various background, both in terms of ethnicity and professional field. At the moment there are 13 universities in 11 European countries which offer EPS as a part of their curriculum. The methodology enhances collaboration and creativity in finding solutions to defined problems, while at the same time providing an opportunity for authors to verify the results by presenting them in front of a large audience. The obligatory midterm and final presentations as well as the external review requirements assures the quality of the results.

The emphasis in the EPS is on team work, entrepreneurial skills and collaborative problem solving. There are four main stages of the project: (1) forming – getting to know each other, (2) storming - developing of shared understanding of the defined problem, adjustment and adaptation to the group environment (3) norming - deeper involvement of participants in the project, (4) performing - implementation, the stage of productive work (Andersen, 2009). The supplementary courses facilitate project organisation, giving students the opportunity to learn some presentation and communication skills. The differing background further enhances creativity.

The Smart City project used the Gantt diagram to plan the team activities. All meetings were carefully documented in minutes. The team defined its identity, adopting the name SmarTeam, where the single 'T' had an additional hidden meaning - it signified better connectivity. At the beginning of the project course meetings were conducted in different places to better integrate the team. Some supplementary activities were also performed like cooking national dishes together or visiting the city centre. The research itself was conducted with the use of multiple and complementary methods: internet and library queries, presence at various lectures and their own recognition of the actual requirements of city life. Among the lectures the one by Jan Gehl, performed in the University of Lodz, was particularly significant. Further work engaged brainstorming. The individual skills of team members were particularly useful in the last phase of the project as it meant it was possible to prepare both the Smartphone application and the whole necessary background including benchmarking, business plan, preliminary evaluation of the interface, etc. The work finished with the final report, which was further assessed by the appointed reviewer and presented for evaluation. The results were satisfactory.

4 SMART CITY AS A STUDY TOPIC - PROJECT IDEAS

The germane areas of research within the wide range of topics covered by Smart City initiatives were addressed in the first phase of the project. The assignment was to find out the meaning of the term Smart Cities and its possible implementations. A dictionary definition¹ of the term which is “*a developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government. Excelling in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure*” served as one of several starting points for establishing the group's own perspective. According to the definition by the European Commission: “*Smart Cities have been characterized and defined by a number of factors including sustainability, economic development and a high quality of life. Enhancing these factors can be achieved through infrastructure (physical capital), human capital, social capital and/or ICT infrastructure.*”². There is an enormous quantity of approaches to the topic which may be found. Among the most recognised ones there are such which emphasise the issues of governance and planning and the social participation and collaboration in defining the goals for future (Batty, 2012; Batty, 2013). The most comprehensive elaborations presume the impact of smart cities' phenomena on science, technology and competitiveness and on society itself (Batty et al, 2012). Other discuss “*revolution intervening in terms of a new infrastructure*

¹ Business dictionary, source: <http://www.businessdictionary.com/definition/smart-city.html>, accessed: 21.12.2013.

² Source: <http://ec.europa.eu/digital-agenda/en/content/defining-smart-cities>, accessed: 21.02.2014

and platform, made of both virtual and physical elements, enabling citizens, users and all different urban players to carry on activities and realize applications thanks to the opportunity allowed by improvements in technology and its widespread presence" (Borruso, Murgante, 2013). The popular understanding of how technology may enhance changes in urban life is expressed as "the marrying of the city, in both its urban and suburban forms, to the telecommunications revolution signified by the silicon chip, the Internet, the fiber-optic line, and the wireless network."³ Although this is not the only one possible.

The students own perspective is outlined in the following considerations: "So what is a Smart City? And how can we define it? As you can see in the previous parts, we tried to understand the main ideas and aspects of Smart Cities. How they should be. How people should feel in such cities. And we figured it out, that the really important thing is just to think smart! Think smart about how you can use new technologies and apply them in the city. How, in a smart way, you can make transportation in the city, easy, fast and comfortable. How not to waste energy but use it? How to make people feel safe and happy in their daily life. How to make them ACT smart."

The important event which strongly influenced the students' views was their participation in the lecture by Jan Gehl on "Cities for People" in Lodz University's Faculty of Economics and Sociology, which took place on 21st October 2013. The lecture, connected with the promotion of the book of the same title, provided them with an insight into more contemporary theories on urbanism and city development. During numerous meetings with their supervisor many talks were watched and discussed, including ones by Saskia Sassen, Michael Batty, Carlo Ratti and others. Other important sources which influenced their perspective were the internet and library queries as well as their own understanding of the current situation, based on individual experiences in the various cities which participants come from or are familiar with, in this case: Lyon, Paris, Madrid and Bilbao. All these insights were contrasted with the local reality of the former 19th century textile industry centre and post-socialist city - Lodz. The project was focused on smart solutions required to improve human life in urban areas. The smartphone application has been developed as a tangible result, inscribing into a more general trend of development of easy and available tools facilitating everyday citizens' life (Townsend, 2013, pp.200-203). The implementation phase included a reality check in the urban environment of Lodz city centre.

4.1 Four fields of a Smart City

The research performed allowed the students to define key fields of urban and technology development and four potential areas of the project development were identified: (1) accessibility, with an emphasis on public transportation, (2) connectivity, including also the broader theme of improving the quality of interpersonal relations and building social capital, (3) green energy and environmental protection and, finally, a wide range of issues under a common name (4) "culture and innovation" Fig 1. (EPS Report, 2014).

4.1.1 City environment

Cities, even if sometimes considered separate from their environment, are ultimately supported by nature and are one of its inherent parts. Through bringing nature into the city, residents can enjoy, on their own doorsteps, some of the ecosystem services that nature provides. In the past, people did not care about building cities which took into account the environment. In addition, the simplification of urban landscape (uniform green areas and parks) could generate a loss of biodiversity. Nowadays, society is trying to respect and protect the environment inside the city, creating green areas, parks and using green energy in order to reduce the pollution of the atmosphere and prevent climate changes.

4.1.2 Communication and relationship

The environment of contemporary cities should enhance not only communication but also the ability to create relationships. One of definitions of communication explains it as "the process by which information is passed between individuals and/or organizations by means of previously agreed symbols"⁴. Technology enables effective circulation of information but on the other hand its speed may constrain the ability to build meaningful relationships, which require time and trust. In a Smart city, effective communication should

³ Source: <http://www.metropolismag.com/February-2014/Big-Data-Big-Questions/>, accessed: 21.02.2014

⁴ Definition by P. Little, source: (2012, 11). Mass Communication. *StudyMode.com*. Retrieved 11, 2012, from <http://www.studymode.com/essays/Mass-Communication-1217118.html>

satisfy a citizen's requirements and anticipate it. It may use codes such as colours, light, sounds, signs, enhance mass collecting of information, i.e., crowd-sourcing, assists process organisation or just provides a communication platform (Hanzl, 2007).

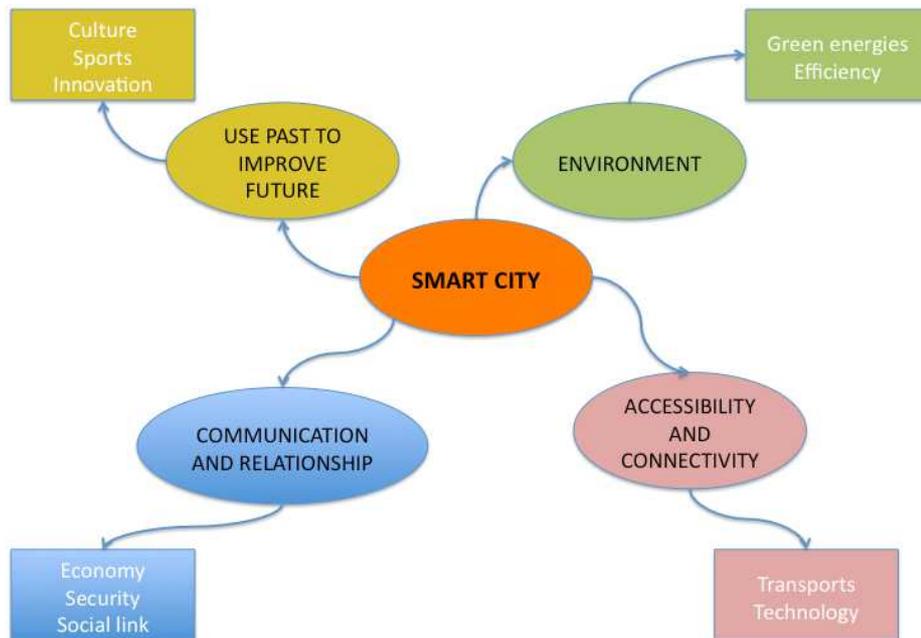


Fig. 1: Graphical representation of Smart City and its aspects. Source EPS Report 2014.

4.1.3 Culture and innovation

Since 2009, when the urban population overtook that outside the urban environment, the problems of urbanised areas have needed solving even more than before. Technology development and social innovations try to answer some of these issues. Although the list of challenges remains long and includes such issues as: promotion of employment and effective resources management. Cities compete to provide comfort, which requires satisfaction of more basic human needs, like: physiological ones, security and safety, education, etc.

The recognition of the city's own culture and history is indispensable as key values for knowledgeable and respectful development. Education services have a role to play with this regard, both with the usage of direct as well as remote communication and presentation methods. In fact every area of human activity may be in one way or another enhanced with the use of technology, whether its sports or musical and theatre spectacles taking place in any spot in a city, they may profit from some technological innovation. The constraints are creativity and organisation, the background is the adjustment to local culture.

4.1.4 Connectivity and accessibility

The transportation system influences both accessibility of goods and citizens' mobility. Both may be enhanced with the use of digital technology implemented for transportation management and organisation. The improvement of a transportation system may also eliminate the need to develop its physical infrastructure by allowing more flexible use of the existing one. Availability of interactive information may increase the comfort of commuters, thus significantly improving travel conditions. Mixed uses and increased densities may make the role of pedestrian movement as a form of transportation more important. All this creates new requirements and opportunities for innovation to make circulating in urban spaces safe, effective and enjoyable. As Senett (2012) admits: " (...) *smart-smart urbanism should follow specific planning principles, privileging the complexity of ground-plane design, recognising the cognitive value of pedestrian experience.*"

4.2 Definition and project ideas

The definition of the term 'Smart City', a result of the former considerations is: "A *Smart City is a place where citizens interact with the city in order to satisfy their necessities (relationship, communication, green energy, economy, connectivity, accessibility, culture) and improve their quality of life using new technologies.*" (EPS Report, 2014). The emphasis on social and cultural aspects of urban development is also

expressed e.g. by Carlo Ratti in his talk 'Decalogue for a "SENSEable" City' (2013), where he talked *"not about technology, but about us"*.

Still, there are several crucial questions to be explored related to current technological development, Batty (2012) listing just a few of them: *"the implications of how the city is being wired, how it is generating new data, how this data might force new theories and models relevant to our understanding, how we might use our strategic models and intelligence to plan the city, building on this new understanding"*. We need to understand the internal structure of the acquired data and look for its efficient and useful applications.

At the same time severe critics of an approach favouring concentration on technology and infrastructure and overlooking the intelligence of citizens and human capacities, as leading to amounts of useless technological innovations, are becoming increasingly common (Boni, 2013). As Saskia Sassen (2012) asserts, cities tend to urbanise technologies. She asks how to implement intelligent systems enhancing urbanisation rather than deurbanising cities. The issue to answer is how to put the technology *"at the service of inhabitants, not the other way around: the inhabitants as incidental users."* Sassen underlines the need to "urbanise" technology which in her perspective means making it work in a particular urban context. This emphasises the difference between the determinative and the coordinative use of technology, which is similar to the one between closed and open systems. The first are fixed and thus oppressive, the second may be further developed and allow flexibility and take into account citizens' needs.

As a consequence of digital technology development, people satisfy their business and communication objectives using remote media. But this hasn't removed the need for direct social interaction, on the contrary, as *"the constraints of geography are lifted, people, businesses and ultimately cities aggregate even more"* (Offenhuber, Ratti, 2014). As William H. Whyte (2009) discerns *"what attracts people are first of all other people"*.

More and more people are interested by the Smart City concept and more and more initiatives try to be an innovative way of supporting local development: (1) to invent new means for consultation and conception of the city, (2) to enhance local resources and identities of a territory, (3) to experiment with new products and services on a digital city, (4) to study new urban uses and (5) to mobilize users, local stakeholders around the territorial project. All the above led the team to propose an application enhancing citizens social needs of direct presence and acquiring knowledge about the city.

5 APPLICATION OUTLINE

A Smartphone application named U-place has been proposed as an answer to the project requirements. It may serve as a social platform allowing citizens to express their opinion on various spots in the city. Its functionality uses crowd-sourcing methodology to gather data on urban places, covering both commercial and public locations, such as: cafes and restaurants, squares and parks. Its functionality also will allow comment on historical and natural heritage sites, where people will be able to evaluate the experience.

The application is intended to help people share their favourite places, thus providing a way to communicate, share opinion about places in the city and promote direct meetings. The places may be added by users along with geographical coordinates, type, photograph and, optionally, a description. Every spot may be assessed based on its quality and price range. Comments may also be added by users. The application is a map-based one and within the map, each place is represented by an icon based on its type or the logo of the enterprise. Upon a click, info on a spot is displayed, consisting of: a photo, evaluation, comments and two buttons for voting on either the quality or price of the place. When a user presses the photo, a description of the place is displayed. The search functionality is also covered. A user may look for a location using such criteria as: name, description, proximity, type and price range. There is also a feedback system, designed to include relevant characteristics of places that may also be used when searching.

The initial phase covered the analysis and design of the app. Further steps need resources to be completed and the estimated budget is included in the final project report. In order to test the application functionality data on various spots in the city centre of Lodz were collected following the chosen criteria. The geo-database was created with the use of Quantum GIS.



Fig. 2: The exemplary screen of the U-Place application. Source EPS Report 2014.

5.1.1 Benchmarking

The final definition of functionality was possible after benchmarking covering existing applications of similar functionalities. The results of the benchmarking is included in Fig 2. It showed that the most similar functionality is offered by TripAdvisor. However it is more complicated and doesn't offer support for the handicapped and hints on transportation availability.

Name	Short description	Platform	Food	Bar	Culture	Profile	Hotel	Comment	Transport	Vote	Handicap
 TripAdvisor	An application used all over the world to organise trips: visits, pubs, hotels, restaurants	Android, Apple	✓	✓	✓	✓	✓	✓	✗	✓	✗
 Avabar	Social application used to meet people and join friends in bars and clubs all over the world	Android, Apple	✗	✓	✗	✓	✗	✓	✗	✗	✗
 Foursquare	An application to find out what there is to do / going out	Android, Apple	✓	✓	✓	✓	✓	✓	✗	✓	✗
 Ville de Lyon	An application used to go out (culture and gastronomy) find out everything that is taking place in this city.	Android, Apple	✓	✓	✓	✓	✓	✓	✓	✓	✗
 MARSAPPS	A set of applications enabling visitors to go out, visit, use transport. Just one function performed by one application.	Android, Apple, Blackberry, Windows	✓	✓	✓	✓	✓	✓	✓	✓	✗
 Insiders' Amsterdam	An application for visiting and finding out what is happening in Amsterdam. Dedicated to tourists.	Android, Apple	✓	✓	✓	✗	✓	✓	✓	✗	✗

Fig. 3: The key features of similar applications. Source EPS Report 2014.

5.1.2 The benefits

The U-place android application offers several technical benefits: (1) time-saving, (2) portability, (3) high availability, (4) flexibility and open architecture. In terms of economy there are a few groups of beneficiaries: (1) application users, (2) institutional stakeholders (restaurants, bars, museums, shops, etc), (3)

application developers. The clients' benefits are the most obvious as they would not only be able to make a better, more knowledgeable choice, but they would also be offered better services thanks to the increased competition between establishments of the same sector. The group of institutional stakeholders may see increased sales due to the popularisation of the application. Social benefits are achieved thanks to the network of relations between consumers/citizens created along with the exchange of reviews, ratings and information on various spots. Increased information may enhance city life and attract more tourists and citizens to use various places and meet there.

5.2 The application analyses and functional requirements specification

The application will be composed of a server-side app and a client-side app. The client app, installed on mobile phones, will contain an interface to interact with the user and ask the server for the information the user requires. The server will store all the important data and will perform the most important processing tasks; including receiving client requests and sending it appropriate responses.

The following list contains all functional requirements to make it easier to get a general vision of the project:

- Adding Information
 - Add a new user
 - Add a new place
 - Add comments on one place
 - Modify place information
- Searching places
 - Location Search
 - User text input search
 - Limited search
 - Mixed search
- Voting for a place
- Displaying information on a place

A detailed description of the application is covered in the specification included in the project report.

5.3 The database structure

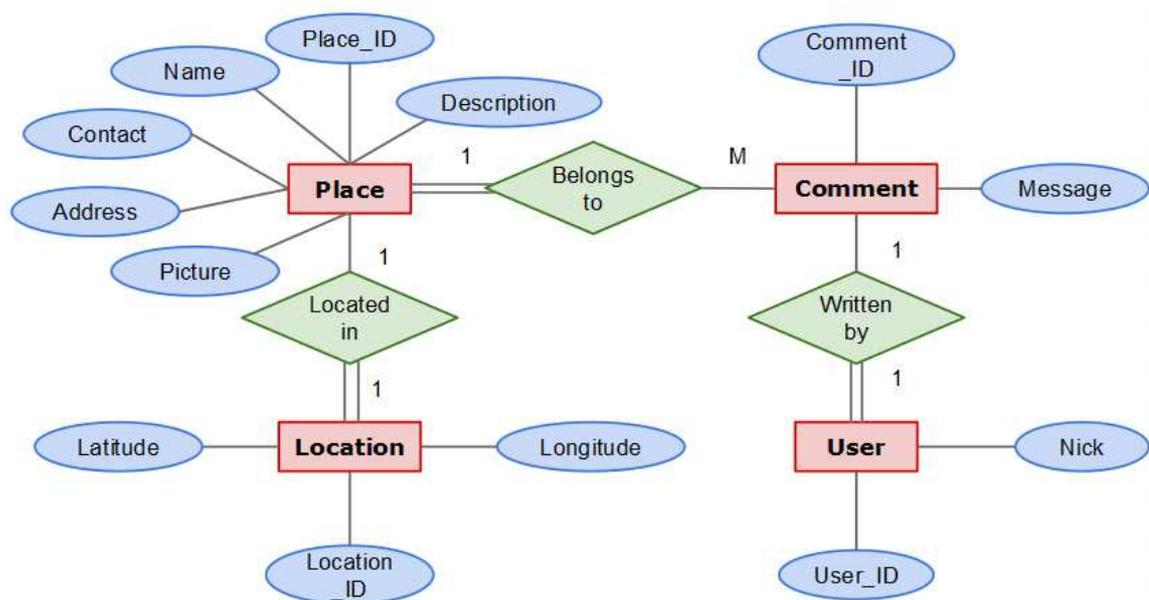


Fig. 4 Entity-relationship diagram

The diagram in Fig. 4 shows the structure of the database, the main entities composing it and their inner relationships in a technical view. Also the the general structure and division in modules of both apps, client and server has been developed. Both the client-side app module diagram and the server-side app module diagram have been defined.

5.4 Statement of the product

During the EPS, a complete analysis of the application was finished, including functional requirements, specification and interface design. Moreover, the most important stages of the design of the app have also been performed, including the architecture design, database design and a complete module design. To get the application finished, there are still some stages to be completed. First of all, the design process should be finished by making class diagrams for all the server code and most of the client code. The second step would be starting to implement the code. The last steps would be the testing and maintenance processes. The recommendation to do this is to use an incremental process, building a small functional prototype in the first instance and improving it with some iterations, using Scrum methodology. This way, testing could be done easily and the development process would be more precise.

6 CONCLUSIONS AND FUTURE DEVELOPMENT

The paper adresses the issue of innovation in education in the field of Smart City technology within the process of education. The project was realised within the framework of the European Project Semester (EPS) at Lodz University of Technology, International Faculty of Engineering, by a team consisting of 5 Bachelor level engineering students of various background, coming from three different European countries. The EPS methodology, concentrated on problem solving, emphasises the teamwork and entrepreneurship of the participants. The initial research on Smart Cities let students define four main areas of possible further activities: (1) accessibility with an emphasis on public transportation, (2) connectivity, including also the broader theme of improving the quality of interpersonal relations and building social capital, (3) green energy and environmental protection and finally a wide range of issues under a common name (4) "*culture and innovation*" (EPS Report, 2014). Their understanding of the topic, enriched with the knowledge coming from various lectures, library and internet queries and their own perspective, led them towards more citizen oriented solutions. As has been stated in the final report conclusions, "*the project was focused on smart solutions required to improve human life in urban areas*". This approach is similar to the one presented by the chief researchers in the field, e.g. Ratti (2013) or Boni (2013).

The U-place Smartphone application has been the result of the project work and may serve as a social platform allowing citizens to express their opinion on various spots in the city. Its functionality uses crowd-sourcing methodology to gather data on urban places, covering both commercial and public locations, such as: cafes and restaurants, squares and parks. Its objective is to "help people to be connected with the city and other citizens". The main phases of the product design has been performed, which are: the functional requirements specification, interface design, architecture design, database design and a complete module design. The design stage was preceded by benchmarking, examining similar applications. Also the budget necessary for further steps has been estimated. The students' project was completed with the final report which was subject to review, and presentation in front of the evaluating commission, following the predefined EPS learning methodology.

The current functionality of the application is simple and easy to manipulate. It allows users to find a desired location, to comment on a place, to add new places and to modify existing ones. Also, the interface remains simple, which is done purposefully to keep it easy to use and attractive from the point of view of young people. The application architecture is conceived as open, so more options are planned if it is developed further, such as connection to a database on historical heritage and reading of QR codes fixed in historical or other important locations. The functionality has been verified with the data describing the neighbourhood of Piotrkowska street in Lodz city centre, collected with the use of Quantum GIS. Further development should also cover other locations. Besides this, users should be able to follow, both places and other users.

The educational process was successful as the EPS method is particularly useful for projects which assume a certain amount of creativity and innovation. The supplementary blocks on teambuilding and project management are very useful for supporting collaboration in a multicultural group. A high level of identification with the team and the project has been one of the outcomes. "*It was the opportunity (...) to*

meet people with another culture and way of working. Sometimes it was difficult for us to communicate and agree but we always found a solution to succeed. Living in another country, we learnt about ourselves too: punctuality, patience, responsibility and working in a team."

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