An International Interdisciplinary Study Abroad Program on Smart Cities

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Abstract—**Preparing the next generation of engineers, scientists and decision makers requires the development of new teaching strategies that follow smart cities philosophy: collaborative, inclusive and focused on specific needs of the region. The University of Texas at El Paso (UTEP), USA and University of Guadalajara (UdeG), Mexico, addressed the challenge of creating a new international course on smart cities study abroad program that leverages the long-term relationship of UTEP with Czech Technical University (CTU), Czech Republic, and industry partners in El Paso and Guadalajara, especially IBM Mexico. This program is highly interdisciplinary, involving four departments in the College of Engineering at UTEP and the Department of Information Systems, Centro Universitario de Ciencias Economico Administrativas at UdeG. Input from city officials in Guadalajara and El Paso along with industry partners was key in designing this novel program. Thirty-two students from UTEP and 32 from UdeG have successfully completed this program which will launch again on its third edition this year. The program included problem-based learning strategies as well as cultural, industry-led activities, culminating in a Smart Cities Hackathon competition. This articles reports on the planning, development and results of this study abroad program, challenges and lessons learned.**

Keywords— smart cities; study abroad; collaborative; international; interdisciplinary.

I. Introduction

We believe that asmart city is characterized by its ability to integrate people, technology and information to create a sustainable and resilient infrastructure that provides high quality services for residents. Transforming a city into a smart city requires collaborative efforts between government, industry, practitioners, residents and researchers. One of the critical steps in the transformation of cities into smart cities is to educate future engineers, scientists, and decision makers about this innovative concept, and providing them the tools and the experience of working in interdisciplinary, collaborative teams across government, and academia. Recognizing and addressing these challenges, The University of Texas at El Paso (UTEP), USA and University of Guadalajara (UdeG), Mexico, with the support of Czech Technical University (CTU), Czech Republic, created a novel a study abroad education program on smart cities. An interdisciplinary team of UTEP and UdeG professors[1] jointly secured a grant from the 100,000 Strong in the Americas Initiative to support the first year of the program development and implementation in 2016. Sixteen undergraduate and graduate students from engineering/computer science students were recruited in UTEP and a corresponding 16 undergraduate and graduate students were recruited from different majors in Centro Universitario de Ciencias Economico Administrativas

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[1] In U.S. universities, the term "faculty" refers to professors. However, "faculty" in Mexican and European universities is equivalent to college in U.S. universities. To avoid confusion, we have used "professor" instead of "faculty" when referring to instructors and mentors, and "Faculty" when referring to a college level entity in CTU.

(University Center for Economics and Administrative Science or CUCEA) at UdeG. Our initial goals were: (i) provide students the knowledge and skills to address problems in the city of El Paso and Guadalajara using smart cities strategies; (ii) provide opportunities for students to work in interdisciplinary, international teams to acquire a global perspective and (iii) advance research and development in smart cities that could be transferred to another city. The program leveraged UTEP's experience in study abroad programs that included physical presence of students in both cities with curricular and extra-curricular activities.

In April 2016, the UdeG professors led their students in a visit to UTEP for a week and in June 2016, the UTEP professors led their students in a visit to UdeG for 2 weeks. During these visits, the students attended lectures on smart cities and related topics. They also attended to field trips. More importantly, they were assigned to bi-national, interdisciplinary teams and worked on projects that focused on smart buildings, smart health care and smart mobility. The final activity of the program was the Smart Cities Hackathon 3 organized by IBM Mexico, supported by the IT industry in Guadalajara and which took place in central Guadalajara. The UTEP-UdeG student teams competed with other Mexican students in the smart buildings, smart health care and smart mobility categories. Upon completion of the program, the UTEP students received academic credit that counts towards their degree plans while UdeG students receive certificates for their participation. The same format was followed in 2017, the second year of this program.

This bi-directional study abroad program took almost two years of effort from conceptualization, planning, proposal submissions, student recruitment and preparation before the actual visits by students to the partner's campuses. The professor-staff organizers encountered and overcame many challenges in the planning and implementation stages of his program. This article documents the planning, the activities, the successes, and the challenges of this study abroad program. The authors hope that this positive experience will serve as a model for smart cities education and motivate other institutions to implement similar programs to facilitate the transformation of cities into smart cities.

This article is organized as follows. After this introduction, we provide the background of the universities with emphasis on their experiences in international programs prior to this venture. Then, we recount the formation of the team, and the activities that led to the funding of this study abroad program. The next section describes the activities organized for the students in El Paso and in Guadalajara. This is followed by sharing the student experiences, challenges faced by the professor-staff organizing team, and how these challenges were overcome. The last section summarizes the lessons learned and suggests possible improvements of this study abroad program.

II. Experience of the Universities

A. The University of Texas at El Paso

UTEP (http://www.utep.edu) is a public university in the State of Texas. It is part of the University of Texas System. The UTEP campus is located on the U.S.-Mexico border, at the western end of Texas. The university has an enrollment of approximately 23,000 students.

The College of Engineering at UTEP has eight academic departments with approximately 3,500 students. Since 2010, the College has been offering several international programs: the Transatlantic Dual Masters Program in Transportation and Logistics Systems (with CTU and University of Zilina, Slovakia) [1], study abroad program in Global and Regional Sustainable Engineering (with University of Piura, Peru), study abroad program in Engineering-Together Sustainable Communities (with Centro de Enseñanza Técnica y Superior or CETYS, Mexico) and Dual Bachelors Degree Program in Metallurgical & Materials Engineering (with Seokyeong University, Korea). To help in the achievement of the goal of 10% of its graduates having international experience, the College has established the Global Program Office with two staff to provide logistics supports to these programs.

At the university level, the Office of International Programs facilitates the visa application process of visiting professors and students, and agreements between universities. The Study Abroad Office has provided scholarships and training to UTEP students who go abroad.

B. University of Guadalajara

UdeG (http://www.ugd.mx/en) is a public university in the State of Jalisco, Mexico. It is the second largest university (with an enrollment of 110,000 students) in Mexico. The university operates out of seven campuses across the City of Guadalajara, and 10 more campuses within the State of Jalisco, plus a virtual campus providing online education. The campus involved in this project is CUCEA. The academic host is the Information Systems Department. The CUCEA campus is the biggest in the metropolitan area of Guadalajara with 20,000 students.

The Centro de Innovación en Ciudades Inteligentes (Smart Cities Innovation Center), established in 2014 on the CUCEA campus, has agreements with the City of Guadalajara, and many industrial partners to conduct research that involves 35 professors and students. Because of this, CUCEA campus is certified by the State of Jalisco as a Living Lab. for Smart Cities Solutions.

The General Coordination for Cooperation and Internationalization (CGCI) is the department at the university level responsible for promoting students and faculty exchanges, collaborative research, and academic programs between UdeG and universities outside of Mexico. UdeG has active student mobility Memorandum of Understandings (MOUs) with 19 universities in the United States. UdeG and UTEP signed an MOU in 2008 that lasted until 2013.

C. Czech Technical University

CTU (https://www.cvut.cz/en) is one of the oldest technical universities in Europe with enrollment of over 23,000 students. The Faculty of Transportation Sciences is one of the eight faculties or colleges in CTU. The Faculty has an enrollment of almost 1,000 students. Since 2010, the Faculty has been collaborating with the College of Engineering at UTEP on the Transatlantic Dual Masters Program in Transportation and

Logistics Systems [1]. The same group of CTU professors are actively collaborating with UTEP professors on smart cities. The Faculty organizes the Smart Cities Symposium in Prague (SCSP) in May of every year since 2015 [2, 3, 4]. Because the focus of the 100,000 Strong in the Americas Initiative is to promote student mobility between universities in the western hemisphere, the roles of CTU in this study abroad program are to support UTEP and UdeG in the teaching activities and in advising students on projects.

III. PROPOSAL REPARATION

A. Formation of Smart Cities Community

The concept of smart cities was introduced by Prof. Miroslav Svitek from CTU to UTEP when he delivered a seminar in UTEP College of Engineering in April 2014. In August 2014, professors from Civil Engineering, Computer Science, Electrical and Computer Engineering, Industrial, Manufacturing and Systems Engineering departments at UTEP and Faculty of Transportation Sciences at CTU formed a special interest group named Smart City Community [5]. In the initial months, the group held meetings to understand the smart cities concept, the language and vocabulary in the different disciplines, and explored possible research and education agenda. The group soon found out that Prof. Victor Larios at UdeG was one of the pioneers in smart cities services, and the City of Guadalajara had been designated by IEEE in October 2014 as its first smart city test site in the world (this IEEE initiative has been renamed as IEEE Core Cities) [6]. Dr. Larios was invited to join the group and after several online meetings the group members from the three universities decided to start the collaboration with a study abroad program. With the most likely source of external funding being the 100,000 Strong in the Americas Initiative, the group decided unanimously that the first study abroad program would be between UTEP and UdeG, with CTU playing a supportive role.

B. Proposal Submissions

The UTEP professors applied for and received seed funds from UTEP's Interdisciplinary Research (IDR) Program in January 2015. These funds supported the visit of selected UTEP professors to UdeG in February 2015 and the writing of the first study abroad proposal which was submitted to the 100,000 Strong in the Americas Initiative (Competition 6) in March 2015. Although this proposal was not funded, the group continued with technical workshops held in UTEP (May 2015), CTU (June 2016), and UdeG (August 2015). In August, 2015, the three universities signed a Non-Disclosure Agreement (NDA) to further their commitments to this smart cities initiative. They presented a paper in the 1st IEEE International Conference on Smart Cities held in October 2016 in Guadalajara, sharing their interdisciplinary experience in working together on this initiative [7]. The second study abroad proposal was submitted to the 100,000 Strong in the Americas Program (Competition 9) in the same month. The group was notified of the award in November 2016.

C. Student Recruitment and Pre-Departure Training

The UTEP-UdeG professor-staff team started marketing the program and recruited students in January 2016. The program was publicized in UTEP through posters, displays on monitors at strategic locations, information sessions and talks by the professors in their classes. In UdeG, applicants were recruited mostly from those students associated with the Smart Cities Innovation Center. Other than an application form, a statement of purpose, two recommendation letters, and their academic record, each student was required to submit a two-minute video of himself/herself that answered specific questions. In the end, 16 UTEP engineering and computer science students and another 16 UdeG's CUCEA students were selected jointly by the professor-staff team in March 2016. They were assigned to eight student teams of four persons per team based on their background, discipline and level of study. The teams were created as diverse as possible in terms of disciplines, gender, countries and experience.

The students immediately participated in mandatory pre-departure orientation activities. Four training sessions were conducted by the College of Engineering Global Program Office and the Study Abroad Office in March and April 2016. They covered:
Session 1: Welcome and program syllabus
Session 2: Workshop on scholarship and finance
Session 3: Health and safety abroad
Session 4: Travel logistics

In March 2016, the Dean, key professors and staff of CUCEA, UdeG visited UTEP. In the same month, a new MOU was signed by the Rector of UdeG and the President of UTEP.

In April 2016, exactly two years after Prof. Svitek's smart cities seminar, this study abroad program was implemented when the professors and students from UdeG visited UTEP for one week. Two months later, the UTEP professors and students made a return visit to UdeG for two weeks. The activities for the students during these periods are described in more details in the next section.

IV. PROGRAM ACTIVITIES

A. Activities in El Paso

The study abroad program kicked-off with the visit of 16 UdeG students and their professors to UTEP from April 20 to 24, 2016. The aim of this visit was to gather all the UTEP and UdeG students in one venue to receive face to face instructions from the instructors. The students also made field trips to infrastructure facilitis in El Paso that have the potential to transform into smart city sites. They also met their teammates for the first time, and started working on the projects for the Hackathon competition. The schedule of weekdays was organized such that the students attended classes in the morning, went to field trips or worked on team projects in the afternoon. In the evening, there were social activities.

The following topics were taught by UTEP and UdeG professors in the classes: introduction to smart cities; systems engineering approach to smart cities; metric and open data; internet of things; smart water resources management; smart

buildings; smart grid; smart mobility. In addition to the technical lectures, the students also learned about business plan development and given challenging assignments to build team spirit. A few lectures were delivered by invited UTEP professors who were not part of the Smart City Community. In addition, students were provided advice for their business plans from the Mike Loya Center at UTEP, a center dedicated to support innovation and entrepreneurship at UTEP. The students also learned the European perspective on smart cities from a visiting CTU professor at UTEP.

Field trips were arranged to the Kay Bailey Hutchison Desalination Plant, Sun Metro bus depot and operations center, and City of El Paso Traffic Management Center. These relatively new facilities opened the eyes and mind of the students. The industry visits also gave students a better idea on how their projects could be implemented in the real world.

The students were given time every afternoon and/or evening to brainstorm for project topics and to develop an initial business plan. Each of the eight teams were assigned a theme (either smart building, smart health care or smart mobility). Themes were selected by UTEP and UdeG faculty based on research directions that the faculty were pursuing and/or were experts on. The teams presented their project contents and business plans to a panel of professors from UTEP, UdeG and CTU in the last day of the visit. The students were given immediate feedbacks to improve the plan between then and the visit of UTEP students to UdeG.

B. Activities in Guadalajara

The 16 UTEP students and their professors visited the CUCEA campus of UdeG from June 5 to 19, 2016. During this visit, all the students continued to receive technical instructions, went to field trips and made progress on the team projects.

In the mornings, the students were given lectures on big data analytics; cloud computing; and smart cities services/applications related to healthcare for senior citizens; smart building for senior citizens; energy systems for smart building; security of smart building; and IBM Bluemix.

In the afternoon, they either worked on their projects or went to field trips. The field trips arranged were to the City of Guadalajara smart cities implementation sites (in the downtown historical district), a senior citizen home, a bike sharing company, followed by IBM and Intel facilities in Guadalajara.

C. Hackathon

The last three days of the program (June 16 to 18, 2016) were dedicated to the Hackathon competition organized by IBM Mexico and held at the MIND Building near the Guadalajara Expo. This competition was opened to all participants but most of the other competitors were students from Mexican universities. A total of 25 teams entered the contest. In these three days, the UTEP-UdeG student teams spent all the time at the Hackathon site to develop their prototype products and services, and presented their ideas to a panel/jury. The panel consisted of staff from the sponsoring IT companies. The UTEP-UdeG student teams entered the competition with the following projects:

TABLE I. HACKATHON TEAMS

Team	Project name	Category
1	APPI	Smart building
2	UbiHealth	Smart healthcare
3	OK Security	Smart building
4	EDC: Every Drop Counts	Smart building
5	Active Elders	Smart healthcare
6	GoBike	Smart mobility
7	ThisAbility	Smart mobility
8	TechCare	Smart healthcare

Three of the eight UTEP-UdeG teams won the first places in the smart building, smart healthcare and smart mobility categories. The smart building project EDC, which was a system to detect water leakage based on noise sensors, was rated as the overall winner.

D. Cultural Exposure

Other than the above technical activities, students spent time in the evenings and weekends to learn about the culture of El Paso and Guadalajara. The cultural activities included:
- In El Paso: city tour; baseball game; morning walk along scenic drive and shopping.
- In Guadalajara: tour of historical center, Tlaquepaque, Tonala, Tequila and cultural show.

A welcome reception and a closing reception were hosted by the College of Engineering at UTEP. A gala dinner was hosted by the Dean of CUCEA at UdeG. In addition, a closing reception was hosted by IBM Mexico after the Hackathon's prize presentation ceremony. These events provided opportunities for students to interact with the Mexican Consul in El Paso, the Deans of both universities, senior staff of IBM Mexico and executives of the Hackathon sponsors.

In 2017, the bi-directional study-abroad program followed the same activities and schedule. However, this time the faculty at UTEP and UdeG defined specific areas of smart cities after discussing needs with personnel of the City of El Paso and Ciudad Creativa in Guadalajara respectively. The second cohort of students participating in this program leveraged some of the project results of the first cohort.

V. STUDENT EXPERIENCE

After the Hackathon, each student submitted a trip report, a video of himself/herself reflecting on his/her own experience as part of their deliverables. They were also asked respond to two anonymous online surveys (one on the technical content and one on the program logistics). The comments from the trip reports and videos were summarized, and together with the survey responses, forwarded to the participating professors and staff, who then used the information, plus their own experience, to conduct a post-mortem.

Based on what was observed from the reports and videos, the professor-staff team concluded that (i) all students had very positive experience with this program; (ii) this program enables the UTEP students to understand the Mexican education system

and culture better; (iii) the team projects were intellectually challenging; (iv) this program had given students the confidence to travel abroad, or to pursue a graduate or PhD degree in other countries. A few students commented that traveling with professors had enabled them to know the professors as a person and a mentor than just an ordinary instructor. One student had mixed experience because of a misunderstanding with his roommate. After the counseling and intervention of the accompanying professors, the critical issue was resolved but the mutual trust needed a longer period to be restored.

VI. CHALLENGES AND POTENTIAL IMPROVEMENTS

Since this was the first time that the professors and staff from UTEP and UdeG collaborated with each other on a study abroad program, they faced many challenges. Some of the challenges and ways to overcome them are reported below.

Some of the professors from UTEP initially knew very little about the Mexican university system, institutional structure and business process. Conversely, UdeG professors and staff also knew little about UTEP. Both partners learned about each other's operating environment as the program was being developed.

The days of mutual visits were decided in January 2016 based on the available dates of key participating professors at that time. The days of visit was not ideal as some students had time conflicts with their regular class schedule. The professors and staff prefer future visits be made during the Spring break followed by a reverse visit in late May or early June. Having the program activities completed by early June could avoid time conflict for students who wish to do a summer internship with industry.

The UTEP professors were initially concern about recruiting non-Spanish speaking students. Fortunately, all the UdeG students were fluent in English, and most of the classes delivered by UdeG professors in this program were in English. During project work, the students adjusted the mode of communication in response to team member's language proficiency. There was a UTEP student, a UTEP professor and a CTU professor in this program who knew little Spanish. They had the opportunity to speak Spanish during field trips, and social and cultural events. Through the abovementioned experiences, the level of Spanish is not a barrier for anyone who wishes to participate in this program.

Once applied and selected, every UTEP student paid a one-time, non-refundable deposit of $300 and registered for a specially created course to demonstrate his/her commitment to this heavily subsidized program. In view of the financial hardship that would be imposed on UdeG students, no deposit was collected from them. In addition, it takes a longer time for a new course to be approved in UdeG. In order not to delay the program implementation, the professor-staff team decided to proceed by letting UdeG students participate without registering for a credit course. Instead they would be awarded a certificate of participation. Because of this lack of motivation,

a few UdeG students left the program in early June 2016, leaving the remaining teammates to complete the Hackathon with less than four members. In the future, all students will be required to pay a deposit and register for a credit course.

The program activities have been described in Section IV. Several students commented that there were too many lectures and field trips, and they wished to have more time for the team projects. The professors agreed that in future, lecture topics and field trips should be directly related to smart building, smart healthcare and smart mobility, or the selected themes. Some of the introductory lectures could be delivered online, or before the first visit. However, activities that foster team work, business plan development should remain in the program.

Based on the experience of the first cohort and their feedback, the amount of lectures was reduced and were replace by activities to work on their projects as well as teamwork activities.

This project has received the support of $25,000 from the 100,000 Strong in the Americas Initiative in the first year of implementation. Both UTEP and UdeG committed to support the professors and staff in the forms of travel grants and summer salary. In addition, the UTEP Study Abroad Office provided each UTEP student in this program a $600 scholarship. From the second year onwards, there was no financial support from the 100,000 Strong in the Americas Initiative. The professors and staff were able to secure funding from UTEP as well as IBM and Ciudad Creativa Digital in Mexico for year two as currently finding ways to sustain the program by keeping the cost as low as possible, and to raise funds from alumni and the industry. One way of keeping the cost low is to fly professors and students from the Ciudad Juarez Airport to Guadalajara Airport instead of flying from the El Paso Airport. This was the practice in the Summers of 2016 and 2017, and the professor-staff team will continue to do so. UTEP faculty was awarded with an International Research Experience for Students IRES: Interdisciplinary Collaboration for Smart Cities that will ensure the mobility of students from UTEP to Guadalajara in the years 2018-2020. UdeG faculty is also pursuing funding for the mobility of UdeG students to UTEP.

VII. SUMMARY

The success of a theme focused study abroad program depends most importantly on the effort of the professors in both universities. First, they must be resourceful in gathering administrative and financial supports within and outside the universities. Repeated attempts to submit proposals is always necessary. The professor-staff team must also have infrastructure support that deals with legal, visa, student recruitment, training/orientation, housing, and travel issues for international programs. If any of the above support functions is missing, the team, with enough determination, can influence the university, or the college/faculty to develop such a capacity. The activities planned for the students must have a good mixture of academic training, cultural immersion and more importantly opportunities for students in both universities to work together.

An excellent activity is a team project which promotes innovation, communications across disciplines, culture exchange and social networking. The professor-staff team must regularly gather feedback from participating students not only to improve the program but also to quickly resolve issues, even in real-time.

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