Campus City project: Challenge Living Lab for Smart Cities

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SUPPLEMENTARY INFORMATION

Smart Mobility

Pedagogic objective: to develop knowledge in the fundamentals of automotive electric and electronics, understanding of different control systems using sensors and actuators, as well as digital-analog conversion and motor digital control.

Stakeholders: This challenge was hosted by an industrial partner, Metalsa®, which is a leading automotive fabricator company in the city of Monterrey. Metalsa® is currently in interest of developing an HEV skateboard, where students will be part of the design process to put in practice the acquired knowledge during the course.

Challenge: to develop and apply concepts and methods for the design of hybrid and electric vehicles, including aspects of energy sources, batteries, motors, mechanical systems and transmis-sions. Students are asked to evaluate the performance of hybrid and electric vehicles in terms of energy consumed, speed, acceleration and load for different configurations. The Challenge in Smart Mobility is entitled “Design and Simulation of Axle Drive Skateboard” which consists in developing a simulation tool to assist in the design and selection of components of the axle drive of a skateboard [1] where executed following a methodology, Figure S1, combining active learning, community context and challenges and a challenge-based learning process. The simulation tool should be able to provide output information on efficiency and performance that helps in the selection of the best electric motor, battery pack, transmission and auxiliary systems.

Methodology:

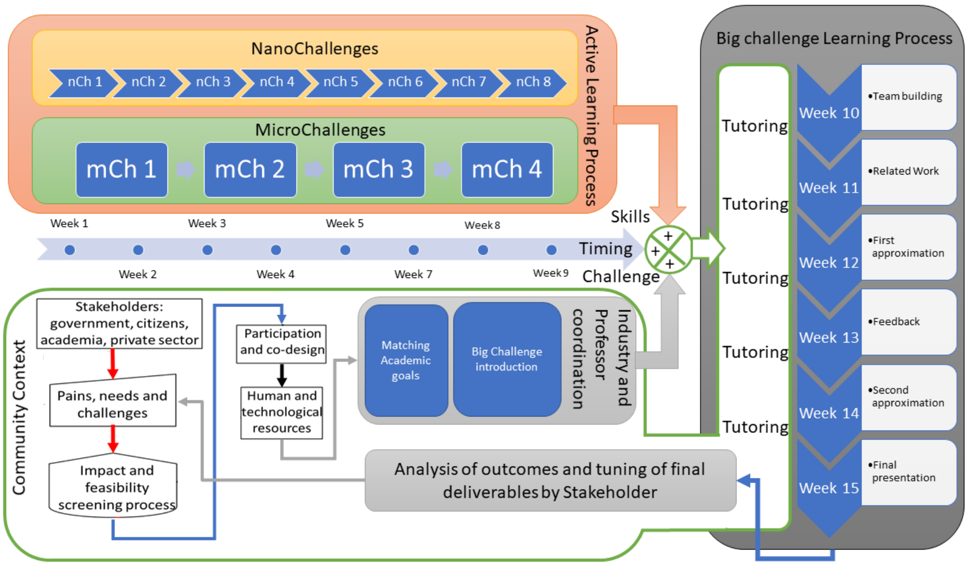

Figure S1. Flow diagram of the overall methodology for the smart mobility challenge. nCh and mCH refers to the nano-challenge and micro-challenge, respectively.

The methodology consisted of three main blocks: active learning process, community context and big challenge learning processes.

The active learning processes enable the interest of the students for the earning of knowledge during 8-10 weeks, one session per week. Each session consists of previous activities, live session activities and after-session activities. In previous activities, the students study videos from other semesters, the video material for the live session and lectures of chapters and or articles. In the synchronous session some problems are solved and nano-challenges are analyzed and discussed. After-session activities consist of micro-challenges with deadline of two weeks among other activities. There were four nano-challenges that guided the students into developing the competencies and skills needed to understand all the variables and components required in the design of a hybrid vehicle that can be used in the context of a Smart City. This includes: 1) to understand and interpret the elements that shape the dynamics of a vehicle, 2) to analyze and understand the factors shaping the elements that resist the movement of the vehicle, 3) to understand and analyze the general equation of the pulling force of a vehicle, 4) to know and understand the environmental impact and technological development historic electric and hybrid vehicles.

Moreover, two micro-challenges were implemented: 1) to do scientific research and documentation, supported with theoretical calculations on the main forces that drive the motion, and main forces that blow energy during and vehicle motion and 2) to study the efficiency of modern electric and hybrid vehicles under an auto-directed research scheme.

Smart Water

Pedagogic objective: to expose students to the water crisis risk in which they initiate a modern problem inquiry from a scientific perspective. This challenge promotes: (1) literature review and concept building; (2) data acquisition and practical analysis; and (3) conceptual analysis from existing models.

Stakeholders: This challenge was co-adviced by an international academic stakeholder expert in emerging water pollutants such as perfluoroalkyl and polyfluoroalkyl substances (PFAS).

Challenge: The Smart Water challenge had 5 main objectives: (1) to understand the concept of "Smart Cities" with a sustainable water management approach, (2) to review local and international laws regarding water quality parameters for the different uses given to water in urban settlements, (3) to search available water related web-data from surface water reservoirs to apply water quality analysis for selected areas within the Mexican territory, (4) to apply water quality models in order to identify the needs for building monitoring programs that lead to the "smart city" mod-el, and finally, (5) to develop an integrated research report proposing solutions based on scientific evidence and available data sources.

Methodology:

A summary of the objectives and activities to be completed by the students is presented on Figure S2.

Phase 1	Phase 2		Phase 3
1) Research and read recent investigations (2017 - present) on "Smart Cities" concepts and applications on sustainable water technologies. 2) Locate "Smart Cities" globally and describe applied methodology between water-energy nexus. 3) Develop a conceptual map or infographics showing water quality concepts, applied technologies, and geographical examples of "Smart Cities". 4) Write a 750-800 word report including: a. Introduction b. Objectives c. Discusion d. Conclusions e. References	Block A - Water Security Perspectives 1) Define water security & the factors that threatens & stress water availability? 2) Which factors are considered to decrease groundwater quality? 3) Identify 3 challenges in order to reach water security? 4) List 5 recommendations for improving water security in Mexico? Block C - Exploring the Tennant method for determining for calculating ecological flow 1) Identify and classify data from given web-database 2) Apply method and create tables and figures for data analysis 3) Write report with similar structure as given reference paper.	Block B - Understanding Water Quality 1) To which basin does your study area belongs to? 2) What are 3 pollutants identified in your area? 3) Which of these 3 (nitrogen, ammonium, nitrates) are responsible for decreasing water quality in your area? 4) Develop a database spreadsheet with retrieved data from web resources.	Block A - Water Pinch method application 1) Identify potential ways of water reuse for industrial processes. 2) Propose optimized distribution network. 3) Estimate water re-use & recovery. 4) Estimate production cost savings for the example industry. Block B - QUAL2K Water Quality Simulaiton 1) Familiarization with software. 2) Model input with given data. 3) Create graphs and tables for environmental analysis. 4) Submit report including both blocks. Create a video discussing the solution.

Figure S2. Objectives and tasks to be completed for the Sustainable Water II course challenge

The challenge is composed of three phases of gradually increasing levels of difficulty. Each phase has an initial research inquiry suggesting a short initial literature review of the topics to assess. The three phases are identified as: (1) exploration, (2) contextualization, and (3) model development.

Phase 1 provides students with the opportunity to explore concepts and characteristics of "Smart Cities" towards water management, quality, and regulations currently identified and applied at international cities. This phase is considered as the "Literature Review" process within any scientific research project.

Phase 2 explores the concept of water security from a global perspective. A brief summary of the principal concepts drawn from policy makers to environmental stakeholders is presented to the students in order to place them into a sustainability context. This assignment is divided in three modules or blocks to ensure proper distribution of the learning phases that the students will undertake (Figure S2).

Phase 3 allow students to evaluate two water quality models to be applied to a given scenario. The proposed models are: Water Pinch Analysis, and QUAL2K. The first one has been widely used as a tool for designing optimal water recovery networks to ensure water conservations form a variety of processes (mainly industrial and agricultural) [2], [3], [4]. The QUAL2K method is a software developed by the United States Environmental Protection Agency (USEPA) for modeling surface water quality in order to find the optimal coefficient and constant values used in environmental projects [5]. This model can be calibrated with five parameters, i.e. BOD, COD, NH_3-N, DO, and SS, from wet and dry season data [6].

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