

Innovation driven by the Sustainable Development Goals and International Multidisciplinary Teams

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Introduction

Fulfilling the United Nation's Sustainable Development Goals (UN SDGs) should be a shared responsibility between governments and society. However, it is difficult for citizens in developing countries to find and secure enough funding to implement sustainable to inadequate regulatory frameworks for innovation and lack of knowledge on how to prepare and present an effective business plan. For that reason, since January of 2018 Harvard University has been teaching a graduate level course in the Yucatan Peninsula with students from Mexico and the United States to understand some of the major problems related to SDGs faced by rural Mayan communities and urban populations around Merida, Mexico. They use these problems as a starting point to create startups in sustainability and health that might help in fulfilling UN SDGs. In this way, PhD and Master Students receive a comprehensive training in new product development, intellectual property, assessment of environmental and social impacts and guidelines on how to write value propositions (for-profit and social ventures) and prepare a business pitch for innovation investors. Students spend 15 days travelling to impoverished urban areas and rural indigenous communities to listen to their problems, understand the cultural context and socioeconomic issues around each problem and gather information from the government and private entities to create new for-profit and social business models to solve problems related to UN SDGs. Past projects created solutions to protect and improve coastal areas (artificial oyster reefs to clean water, recycling of different waste streams from cruise ships to create jobs and sustainable building materials, etc.), improve mobility in Mayan archaeological sites like Chichen Itza and Uxmal, significantly reduce poaching and traffic of endangered species through social programs, improve drinking water supply for urban and rural indigenous communities and foster the development of renewable energies and sustainable agriculture in the region. At the end, they deliver a business plan and business presentation that deals with solving an SDG and a strategy on the way forward to secure funding from international innovation investors to create a multidisciplinary and international startup that solves real community issues in developing countries. This is a model that could be implemented in other regions of the world with similar characteristics.

Harvard winter Courses 2018 and 2019 in Yucatan, Mexico

The "EH 210 Social and Sustainable Innovation driven by the Sustainable Development Goals" winter course was offered by the Harvard T.H. Chan School of Public Health in Yucatan 2018 and 2019. Each time, twelve Harvard PhD and Master students attended the course in Merida (the capital of Yucatan). Twenty Mexican students from different universities in the city attended the course along with the Harvard students. Each winter course lasted 15 days. Harvard professors and teaching assistants (Sanchez et al., 2018)

carried out these courses and worked together with local university professors.

Why higher education students?

Higher education student can propose very important projects related to SDGs. Moreover graduate students can choose topics directly related to SDGs as thesis topics or specialized work. These courses help students to develop topics based in SDGs and prepare them to get funds to fulfill these goals.

The state of Yucatan in Mexico has a high percentage of extreme poverty, but this situation can be reduced by focusing many of its 80,000 students and one hundred higher education institutions to implement projects related to SDGs. The Harvard course aims to increase the percentage of projects related to SDGs, particularly among Yucatecan students. Each year more local universities are interested in participating in the Harvard course.

The course

A big percentage of new ideas are likely to be conceived and implemented in developing countries which may require to strengthen their frameworks and capacity to conceive and implement innovation initiatives under their local conditions. For that reason, public health professionals should become agents of change that empower people worldwide by sharing knowledge and developing skills in sustainable practices and technologies, climate change preparedness, social entrepreneurship and the process of creating positive startups to implement sustainable and social innovation to help in achieving SDGs.

This course examined the relationship between SDGs, community problems and current sustainable and social solutions to serve as a starting point for developing new solutions that might serve as the business or social cases for new startups in health, sustainability or social ventures.

This course was taught in the State of Yucatan in Mexico during January of 2018 and 2019. Students from Harvard University took classes along with students from the local universities and worked in multi-national teams to assess community needs, prepare climate change vulnerability and resiliency enhancement plans, design health and social solutions to problems to serve as the business case for sustainable startups, develop business or social plans for potential investors, engage the community into participating in developing and implementing solutions and in recommending frameworks to enhance sustainable and social entrepreneurship in a community.

Some of the topics for the course were:

- Sustainable Development Goals as drivers of sustainable, health and social initiatives
- Assessment of health and environmental beneficence of new ideas to achieve SDGs based on scientific tools developed by public health professionals
- Assessment of community vulnerability and resiliency development to the effects of climate change
- The process of identifying and understanding community needs to engage people into participating in achieving the aims of SDGs
- The process of creating social, health or sustainability startups based on SDGs, community needs and climate change preparedness activities
- The process of using health and environmental benefits of sustainable or social value propositions to strengthen the business cases to help funding activities with innovation and social investors

Learning Objectives

Participants in the course learnt how to:

- Have a deep understanding of the Sustainable Development Goals and how they support environmental and health protection worldwide
- Identify what are the potential social and economic benefits of SDGs and how that relates to resilient and healthy communities
- Identify and use the right methodologies to assess social, health and environmental community needs through climate change vulnerability assessments
- Compile and record lessons learned from the past from indigenous communities to help in reducing climate change vulnerability and enhancing community resiliency for other societies in the future
- Transform the needs of a community into new social and/or technological ideas to solve problems in a sustainable way (clean water, renewable energies, prevention of infectious diseases, enhancement of human comfort in buildings, enhancement of the built environment and protection of the natural ecosystems, etc.)
- Use the basic new product/service development process to create new technologies and/or services that enhance environmental and human health protection.
- How to use techniques to enhance customer-driven design for sustainable and social solutions by engaging local people into the new product/service development process and in defining conceptual designs that work for them and for their communities
- Use proper scientific methods for estimating and comparing the impacts of conventional VS sustainable and/or social technologies and practices and how to use this information to build the business or social case for a startup
- Apply community-based participation and benefit-sharing of revenues with local people to consolidate participation in prevention of infectious diseases, renewable energy and energy efficiency projects and in creating traction for new sustainable and social startups
- Create a sustainable, health or social startup from scratch and the process of writing a business plan to assess and manage risks properly to increase the chances of getting funded
- Identify the main components and use global lessons learned to create a sustainable and/or business plan for sustainable, health or social startups
- Characterize types of innovation and social investors and determine how to deal with each one of them to support positive startups that support the process of achieving SDGs (Angel investors, venture capitalists, venture philanthropists, foundations, aid agencies, crowdfunding, co-ops, etc.)
- Prepare effective presentations to pitch a startup to different types of investors based on the type of business and/or social proposition by enhancing the idea of fulfillment of SDGs, overall environmental and health beneficence and potential social benefits of a new venture
- Use techniques to prepare a rural or developing community into creating frameworks to support social and sustainable entrepreneurship to create positive startups and connect them with innovation investors around the world to enhance funding opportunities for companies actively supporting the achievement of SDGs

Work groups

Since the first class work groups were formed with Harvard and local students. During the first days they explored Merida city, took photos, visited the market and downtown. They began to get information and detect problems. Students programed interviews with government officials and local people, visited some places like the garbage disposal place and stone factories which are abundant in Yucatan. All students used actively the class

platform to load and download information and getting relevant papers to read before the class. All groups had to participate in an active way to share the information they got. All groups had a multidisciplinary profile; different careers were present as: architects, digital designers, engineers, scientists, etc.

The state of Yucatan in Mexico

To understand the actual situation in Yucatan regarding water, students visited natural geological formations that serve as water sources. Yucatan was the epicenter of an asteroid impact 65 million of years ago, as a result, interconnected underground caves called “Cenotes” were formed; there are more than 2,241 thousand “Cenotes” in Yucatan, and they are forming a ring around the impact point within a 180 km radio. These “Cenotes” contain water and people have used them for centuries, Ancient Mayan people considered them sacred places, a lot of Mayan cities were built near these formations. Nowadays rural communities are promoting them as ecologic and touristic sites. But many Cenotes are suffering pollution. Students visited a Cenote called Xcayun (a Mayan word that means “the place of sounds”) near Chichen Itza and they also visited the Chichen’s sacred Cenote, see **Figure 1**. The Yucatán Peninsula karst aquifer is one of the most extensive and spectacular karst aquifer systems on the planet (Bauer-Gottwein et al. 2011, 507), it has a great quantity of freshwater but part of it is threaten by pollution and bad human practices (like disposing of garbage in the cenotes). Lately a lot of companies have being built factories to extract water to prepare beverages. Yucatan exports pork meat and a lot of farms have been created in rural communities near the “Cenotes” and problems have emerged due to this situation. Animal waste from farms can pollute underground aquifers. Another important activity is the rock extraction, Yucatan is a rocky plane platform, its rock is one of the hardest of the world, and many companies have been created to export construction materials. Students visited a rural community where people make sculptures and create objects with stone, students proposed a project to improve the health of workers that were inhaling course particulate matter from stone cutting operations which might lead to asthma, respiratory and cardiovascular diseases. Some students also prepared a project to increase drinking water availability in urban and rural communities to reduce the use of the plastic bottles.



Figure 1. The ancient sacred “Cenote” in Chichen Itza, Yucatan.

The Ancient Mayan Culture and its collapse

A lot of ancient Mayan cities were built near Cenotes in the north part of Yucatan (water is about 6 m deep), but some of them were built in the south part of the state (where water is about 100 m deep). These southern cities obtained water by collecting it from the rain, now it is possible to observe underground deposits in Uxmal called “*Chultun*” (a Mayan word). A long time ago when drought arrived (between 800 and 950 AD), Mayan cities in the south began to suffer from lack of water and many people started to migrate, so southern cities were abandoned, and commercial and cultural activities stopped in the area. Lately divers found ancient ceramics at a depth of 30 m which were used for ceremonial activities in some cenotes, this indicates a lower water level in the past. Ancient Mayan people suffered from Climate Change that led them to cultural and economic decay and to their assimilation by other Mesoamerican civilizations until the Spanish Conquest in the early 16th Century, a local professor who published about that (Cobos et al. 2014), talked to students about the history Chichen Itza and Uxmal and afterwards they visited both archeological sites, see **Figures 2- 4**. In Uxmal, the students listened to a researcher and curator of this old Mayan city and gave them a guide to learn the Mayan hieroglyphic system. In the chocolate museum near Uxmal, they tasted chocolate beverages prepared in the traditional Mayan way, see **Figure 5**. Due to importance of the ancient Mayan culture, Yucatan has a lot of tourists and it is an opportunity to propose new startups that might solve some community problems related to the fulfillment of the UN SDGs. Students visited two ancient Mayan cities (Chichen Itza and Uxmal) to learn about the development of these important ancient cultures and how the construction of big Mayan cities created a tree devastation and a change in the environment that later led them to demographic and societal decay.



Figure 2. Harvard students visited Chichen Itza in 2018 and 2019



Figure 3. Students in Uxmal listening to an expert in 2018.



Figure 4. The group visited Uxmal in 2018 and 2019.



Figure 5. Professors and students tasting chocolate in a museum near Uxmal.

Merida City, the capital of Yucatan

Merida was built on an ancient Mayan city; it was founded in 1542 by the Spaniards. Merida downtown has a lot of old colonial buildings. Nowadays it has around one million inhabitants. Merida is one of the most important cities in southern Mexico. Today Merida is the most secure city in Mexico (has the highest security index in Mexico, and it is within the sixty most secure cities around the world). Merida has the main universities and institutions of higher learning. Harvard students took classes in various public and private universities, they also took classes in various municipal buildings (like the Merida Entrepreneurship Center), as well as private conference rooms offered by non-governmental organizations (NGOs). In Merida, students listened to government officials who talked about local problems like waste disposal, unplanned urban growth, the noise effects of commercial and hospitality businesses in downtown, and so on. They also listened to the issues raised by NGOs like protection of biodiversity and endangered species, the lack of good programs for sustainable development in rural communities, etc. Yucatan has now around eighty thousand higher level students and one hundred institutions of higher learning.

The coastal zone

Yucatan is the first exporter of octopus in Mexico. The coast of Yucatan has 378 km along the Gulf of Mexico and the Caribbean Sea. Fishing and tourism are important activities in Yucatan. Along the coast there are a lot of small ports. The most important port in Yucatan is Progreso (36 km from Merida) which has one of the longest harbors around the world (7.5 km length). Students visited this harbor and listened to federal government officers who

talked about the harbor activities: export-import, cruise ships arrivals, oil supplies (PEMEX activities) for all peninsula. Along the Yucatecan coast there are marshes with a lot of mangroves and natural reserves where you can observe flamingos. In Yucatan there is a big factory which produces salt for the oil industry and for human consumption. The students visited a natural reserve in Progreso where they observed wild animals, an eco-tourism coop operated by fishermen that provide boat services to visit the natural reserve, students observed the fragility of the ecosystem because it suffers from flood and pollution problems by the urban growth, see **Figure 6-8**.



Figure 6. Professors and students visiting a natural reserve in the Port of Progreso.



Figure 7. Professors and students observed a lot of wild animals in the natural reserve.



Figure 8. Professors and students talked about the problems in this natural reserve.

Students proposed a project to mitigate and prevent animal poaching and traffic of endangered species and another one using the garbage of cruise ships to produce electricity and construction materials for Puerto Progreso. Wind has been studied in the Yucatan coast for fifteen years, so the first wind farm in the region was built in the port of Dzilam (80 km from Merida), students visited it and listened to engineers from the company. The farm has 28 wind turbines (120 m in height) with 2.5 MW of capacity for each one for a total capacity of 70 MW. In 2018 the farm was under construction, now in 2019 the farm is operating, see **Figure 9**.



Figure 9. Students visiting a Wind Farm in the port of Dzilam in Yucatan, in 2018.

Rural communities

Yucatan is the first honey bee exporter in Mexico, honey is collected in rural communities, more than 50 % of all inhabitants in Yucatan are Mayan indigenous populations. Yucatan had a poverty index of 41.9 % and an extreme poverty index of 6.1 % in 2016 (Gobierno del Estado de Yucatan, 2019). Students visited two rural communities: Santa Elena in 2018 (named Carlota Village, during the second empire in Mexico in XIX century) and the small town of Mani in 2019 (where a lot of ancient Mayan codes were burnt, and a lot of Mayan people were killed in the 16th Century). In Santa Elena (100 km from Merida) students visited a typical rural house and the community, professors and students prepared “tortillas”, and tasted a regional meal (Mayan pork barbeque prepared in an underground pit), visited a typical Mayan house made with natural materials, they observed how people sleep into the

house using hammocks, visited a typical yard where a Mayan ceremony was carried out, and they made ropes with natural fibers (from a plant named “*henequen*”, which detonated the Yucatan economy in 19th century). In 2019 a rural ecological school (Escuela ecológica de Mani) was visited by students for six hours, here the students had a special class, see **Figure 10**, professors and students participated in activities in which they carried out practices: work with a special and an endemic stingless bee called “*Melipona*” which Mayan people have cultivated for centuries; prepared medicines with natural plants in a small rural lab; cooked in a traditional way (students helped to prepare a special pork barbeque which was buried) and to make “tortillas” see **Figure 11**; planted tomatoes see **Figure 12** and prepared composting for fertilizing agricultural soils. Students had lunch in this school. This school (85 km from Merida) has been teaching rural people to improve their lives for twenty-one years, it is an NGO which operates as a private school and now it has economic problems. The school has promoted digestors to produce methane for cooking, this system is used in the school, around two hundred families have received this system during the last ten years, a lot of them are working but many need repairs, people do not know how to fix them. Students prepared a project to protect Mayan bees from extreme heat during the summer. A drone was used to have a record of the school’s layout before departure **Figure 13**.



Figure 10. Professor Sanchez with the Director of the Ecologic School in Mani.



Figure 11. Students and local women preparing “hand-made” corn tortillas



Figure 12. Professors and students planting tomatoes in the rural school in Mani.



Figure 13. All professors and students after the classes in Mani, Yucatan.

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