Urban Raised Bed Vegetable Garden Designed to Promote Immunonutrition: A Pilot Study

Patricia Mehner-Karam[1,*], C. A. Gutiérrez[2], Juan M. Casillas Pintor[3], Miranda Ori-Orlansino[4], D. A. Perez-DeLaMora[4], Mariana Ruiz-Morales[5], and Eduardo Gamaliel Hernandez-Martinez[4]

[1] Health Department, Universidad Iberoamericana Ciudad de México, Mexico City, Mexico
[2] Department of Chemical, Industrial and Food Engineering (DIQIA), Universidad Iberoamericana Ciudad de México, Mexico City, Mexico; Email: cesarmcig@gmail.com (C.A.G.)
[3] Department of Architecture, Urbanism and Civil Engineering (DAUIC), Universidad Iberoamericana Ciudad de México, Mexico City, Mexico; Email: juan.casillas@ibero.mx (J.M.C.P.)
[4] Institute of Applied Research and Technology (INIAT), Universidad Iberoamericana Ciudad de México, Mexico City, Mexico; Email: {huertourbano, daniel.perez, eduardo.gamaliel}@ibero.mx (M.O., D.A.P., E.G.H.)
[5] Engineering Department, Universidad Iberoamericana Ciudad de México, Mexico City, Mexico; Email: mariana.ruiz@ibero.mx (M.R.)
*Correspondence: patricia.mehner@ibero.mx (P.M.)

***Abstract*—In recent years urban agriculture practices have been developed to increase the self-production and self-consumption of fresh and varied foods. While food security in cities continues to decline and several diseases become more frequent in city inhabitants, it is important to implement urban gardens as a potential alternative for families to obtain fruits and vegetables to incorporate into their meals, especially when the supply of these is restricted as happened with the lockdown for the COVID-19 pandemic. In this study the design and implementation of a raised bed urban garden to be tested in western neighborhoods of Mexico City was achieved. The project was divided into four stages: (i) design and development of the prototype garden, (ii) selection of the vegetable palette to promote immunonutrition, (iii) production of educational materials for planting and caring for the garden and (iv) validation. The alternative of urban gardens that provide a variety of plant species that are easy to grow in urban microclimates promotes a sustainable culture by taking advantage of new technologies and virtual education (e-learning), which help guarantee their use and permanence.**

***Keywords*—agricultural education, immunonutrition, raised bed vegetable garden, sustainability, urban garden, vegetable palette**

I. Introduction

With the COVID-19 pandemic, the need to grow vegetables that promote immunonutrition in a family garden was identified. For this reason, the multidisciplinary research team working at the urban garden called "Huerto José de Acosta, S.J." (best known as "Huerto Ibero") took on the task of designing a vegetable palette as well as an easy-to-assemble urban raised bed vegetable garden to start growing food at home.

Manuscript received May 5, 2022; revised May 26, 2022; accepted October 1, 2022; published March 30, 2023.

The Huerto Ibero (HI) is a recent initiative of the Universidad Iberoamericana Ciudad de México. It is aimed as an experimental space for materializing proposals based on scientific and technological research with the purpose of generating and putting into practice applicable and replicable solutions to the immense problems of food insecurity and climate change facing Mexico and the world. The main goal of this urban garden is to promote the gathering and interaction of the university community, linking student organizations, academic departments, and staff contributing through the combination of training and participatory practices to the teaching of urban garden practices to trigger synergies and exchange of knowledge, promoting research.

Based on the years of experience and operation of the HI, this project sought to contribute to the health of the community and to respond to food insecurity generating plant life and harvests of appetizing vegetables in a garden at home to prepare healthy and delicious dishes and menus, motivating a nutritious diet to help strengthen the immune system. Urban Gardens can be a good alternative for families to facilitate consumption of vegetables and fruits when their price and availability are compromised due to logistic problems such as the COVID-19 pandemic lockdown.

The Food and Agriculture Organization (FAO) has described that there is no specific food that can prevent infection. Nevertheless, it is well demonstrated that the person who ingests a proper diet covering the characteristics of immunosuppression can respond to an aggressor agent with a better chance of success with their innate immune system to the inflammation that triggers an infection. The FAO recommends strengthening the immune system through the consumption of at least five servings of fruits and vegetables per day, legumes at least three times a week, foods of animal origin in moderation must also be included and drinking at least two liters of water a day [1]. If these choices are joined with a proper diet, immunonutrition can be favored.

Immunonutrition is defined as interventions with specific nutrients with potential to modulate the activity of the immune system. It is a relatively new discipline, which includes the relationship between different aspects related to immunity, nutrition, infection, inflammation, and damage to body tissues [2, 3]. Nutrition from a correct diet is a determining factor in developing an adequate functioning of the immune system throughout life. In this context, immunonutrition can cause the response of the innate immune system to modulate the inflammatory response to an infection. There are other factors specific to each human being that interfere with this, such as age, genetic polymorphisms, the intestinal microbiota, the existence of pre-existing diseases, the hormonal status, as well as the quality and quantity of sleep and physical activity [2]. If we can incorporate more fresh ingredients into our diet, micronutrients, and fiber naturally present in vegetables and fruits, intake of vitamin A, C, D, beta-carotene, iron, zinc, copper, arginine, glutamine, and omega 3 essential fatty acids [3, 4], among other nutrients will be ensured, which at this time can function as a modulating factor of the pro-inflammatory cytokine cascade or storm triggered by COVID-19.

This pilot study had a high educational and pedagogical relevance in the perspective of environment and sustainability. The development of different theoretical-practical knowledge around the design and maintenance of family gardens facilitated the acquisition of skills such as systemic thinking, anticipatory thinking and collaborative work which are key to trigger a greater sense of belonging and care for the processes that make life on Earth possible. From an ethical point of view, this is essential in any educational proposal that seeks to build sustainability and social justice.

Taking advantage of educational benefits, it has been widely documented that environmental education combined with virtual education makes an interesting combination in the construction of capacities aimed at sustainability in any field. E-learning can help to transform the way people learn and will in a certain way by immersion in Information and Communication Technologies (ICT) [5‒8]. And including a situated learning approach seeks to facilitate the revaluation of the local context as a central element of education [9] favoring both flexibility and democratization of knowledge [10].

II. METHODOLOGY

This study was carried out from July 2020 to December 2021 by a multidisciplinary group in charge of the design and implementation of each of the components of an urban raised bed vegetable garden to be tested with 5 families from the neighborhoods nearby Santa Fe, in the west part of Mexico City.

For the design of the family garden, the following elements were considered:

(1) A low-cost and accessible structural garden raised bed design, to be implemented by anyone, especially low-income people.

(2) A low-cost vegetable palette with nutrients that strengthen the immune system (Immunonutrition), obtained by a review of the state of the art and surveys with the target population of Mexico City.

(3) Effective training and operation instructions for assembling the raised bed, planting, harvesting, and preparing recipes through specifically designed videos, manuals, and booklets.

(4) Validation of the previous points, by training a total of five families who installed their raised beds, evaluating the clarity of the instructional materials and the adoption of this eco-technique.

The methodology of the raised bed design and the vegetable palette design, preparation of educational materials and the validation of the pilot study are described in the following sections:

A. Raised Bed Design

From the first stage, it was necessary to identify analogous cases with low-cost, low-maintenance, and flexible designs. Backs *et al.* [11] demonstrated how a design with these features can improve plant survival rates. Similarly, there have been efforts to create a low-cost smart gardening kit using devices connected to the Internet of Things (IoT) and thus promote sustainability and collaboration in community gardens [12].

There are several patented designs mainly focused on the effective use of space and common household elements to install a vegetable garden; such is the case of the window-mounted plant box (United States Patent No. 3946522, 1976) [13], which is mounted on the window frame and thus allows the plants to receive direct irradiation. Additionally, there are modular systems for a section assembly with trays for different uses (United States Patent No. US 2015/0201563 A1, 2015) [14], and others where the use of interchangeable slotted panels allows an intuitive assembly (United States Patent No. US 9655307 B2, 2017) [15].

The second stage results can be consulted in the section vegetable palette design that promotes immunonutrition. The characteristics of the different crops were considered for the design of the different heights, depths, and dimensions of the raised bed. In the third stage, different sketches were generated (see Fig. 1) with the necessary characteristics to satisfy the requirements of the vegetable palette. Three-dimensional models were created (see Fig. 2) to validate the raised bed structure's integrity and safety. Finally, from the outcome of the previous design stages, the design criteria and specifications were generated and implemented in a functional prototype (see Fig. 3).

Figure 1. Concept design.

Figure 2. 3D preliminary models.

Figure 3. Final functional prototype.

B. *Vegetable Palette Design*

The design of the vegetable palette was based on the documentary research carried out at the beginning of the project, to integrate the characteristics of the different crops focused on immunonutrition, having identified 38 species susceptible to be planted in a raised bed [16−20].

A survey was carried out in a focus group of 83 beneficiaries of Centro Ibero Meneses and Santa Fe Community Center to consider the social context, customs, and preferences of the families.

The results were analyzed with data science methods carried out in the BigML® platform. Fig. 4 shows an association diagram connecting the main preferences of the families. On the other hand, Stata22® identifies 4 latent profiles from the consumption frequency survey (see Fig. 5). From this analysis, tomatoes appear as the most preferred species in all of them. The following table shows which are the most preferred species in each profile. Those species that were strongly repeated in several profiles were selected.

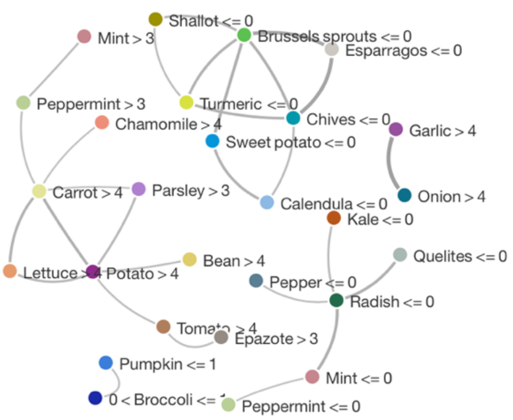

Figure 4. Association analysis about vegetable preferences.

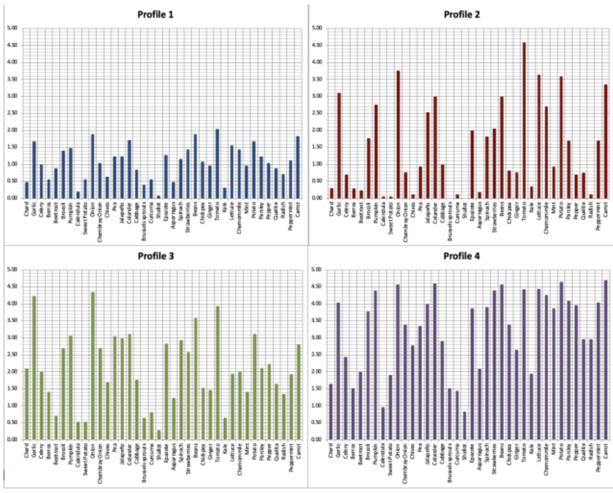

Figure 5. Analysis using Stata22®.

Next, another analysis was conducted to better identify the final preferences from the highlighted species of the 4 profiles, taking as a cut off value a median of 3 or greater (Fig. 6). Box plots for the scores in each vegetable.

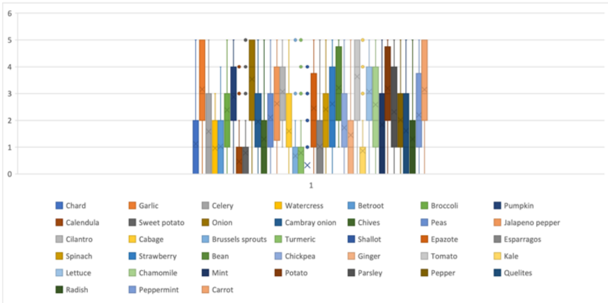

Figure 6. Box plot of preference of the vegetables.

After these analyses, it was required to balance diversity and quantity aiming at optimizing consumption availability given the different harvest times among crops. Finally, 19 species were chosen in order to meet the characteristics to promote immunonutrition with crops regularly used by the families. The most important thing in this stage was to consider the common eating patterns of the participants so as to design a vegetable palette which could be both useful and appealing.

The final vegetable palette included: Lettuce (*Lactuca sativa L.*), tomato (*Solarnum lycopersicum*), spinach (*Spinacia oleracea L.*), radish (*Raphanus sativus L.*), onion (*Allium cepa L.*), garlic (*Allium sativum L.*), beetroot (*Beta vulgaris L.*), chard (*Beta vulgaris*), oregano (*Origanum vulgare* or *Lippia graveolens*), thyme (*Thymus vulgaris L.*), chives (*Allium shoenoprasum L.*), basil (*Ocimum basilicum*), parsley (*Petroselinum crispum*), coriander (*Coriandrum sativum L.*), epazote (*Chenopodium ambrosioides*), chili pepper (*Capsicum spp.*), calendula (*Calendula officinalis*), chamomile (*Anthemis nobilis*) and potato (*Solanum tuberosum*).

To promote good growth, short-cycle and long-cycle crops were included in the design of the vegetable palette. Symbiosis between crops was also considered to prevent the presence of pests. Staggered planting strategy was planned to allow constant harvests from short-cycle products while long-cycle ones advance in their growth. Harvest education was included from seed germination to cropping in order to cover all harvesting steps.

A six-month cycle palette was proposed to later renew the substrate, ensure nutrients in the crops, and avoid diseases and pests. The suggested mix of substrate was: 60% mountain or black soil, 10% leaf soil, 20% vermicompost, 10% agrolite, rock flours, silos of water and coconut fiber. The substrate was consistent in all the raised beds piloted and was purchased from the company "Cultiva Ciudad" in Mexico City.

The main care and requirements for the optimum growth and development of the raised bed vegetable gardens included 4 to 7 hours of sun, watering 2 to 3 times a week as needed and weekly maintenance to prevent weed growth and to identify plagues in early stages. Finally, the vegetable palette and its cycle are illustrated in Fig. 7.

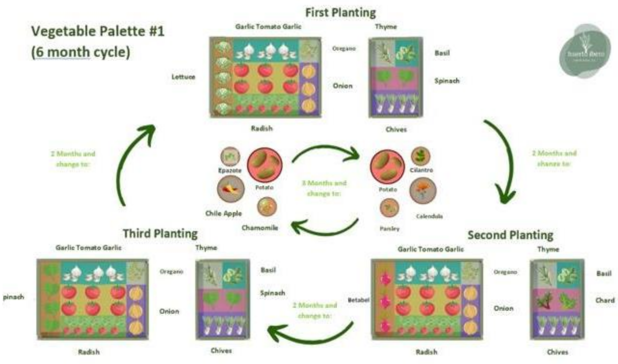

Figure 7. Vegetable palette.

C. Preparation of Educational Materials

Several educational materials were created so that the families could understand how to assemble the garden, learn about the plants in the vegetable palette and their properties, acknowledge the socio-environmental benefits of having a raised bed vegetable garden at home and to learn new healthy recipes using the species to be harvested.

The platforms and programs used to create the materials were mainly Doodly®, TikTok®, Word®, Canva® and AutoCAD®.

All educational materials were created with a common and simple design, and with a structure and language understandable by all audiences. It is intended that the educational materials not only reach the families of the present study project but also individuals interested in urban gardens, sustainability, and healthy nutrition.

D. Pilot Study

In order to evaluate the feasibility of the proposal for a urban raised bed vegetable garden, the pilot study included 5 families from nearby neighborhoods to Universidad Iberoamericana Ciudad de México: Peña Blanca, Tecolalco, La Cebada and Santa Fe (see Fig. 8).

The families together with researchers kept a field diary (research log) collecting experiences through pictures and semi-structured questions every two weeks (presence of pests, remedies used to attack pests, harvests in the last week, number of dishes cooked with the harvest, problems with the structure of the raised bed, mood and physical changes and overall satisfaction).

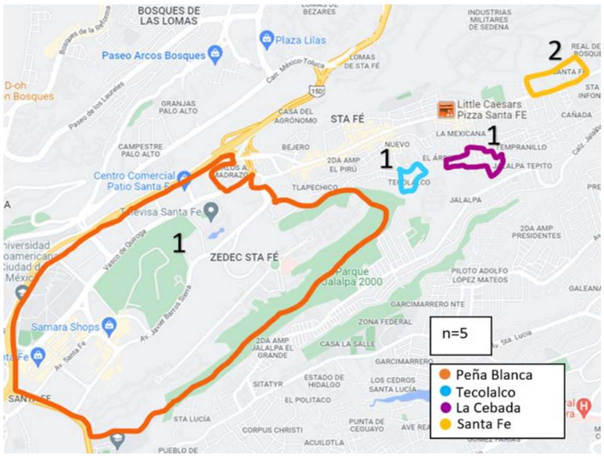

Figure 8. Map of the five family neighborhoods near Universidad Iberoamericana Ciudad de México.

III. Results

Along with the raised bed design and its implementation, other results obtained from this project were the educational materials: a written and illustrated assembly manual, an animated video explaining step by step how to assemble the raised bed to obtain the desired final structure, an infographic vegetable palette which graphically explained the necessary crop rotation to be carried out during a six-month period, five scripts written for the informative videos, nineteen animated videos about each plant made on Doodly®, six videos on TikTok® about socio-environmental benefits of urban gardens, three professionally recorded videos about planting, harvesting and caring for the plants in the vegetable palette, a recipe e-cookbook containing fifty-four healthy recipes and six videos on TikTok® explaining some of those recipes.

Due to COVID-19 lockdown researchers were not able to visit the families and have direct contact with them, so contact for follow ups with the research log was maintained by text messages. Some communication problems were faced with one family. Fig. 9 shows the raised bed vegetable garden with harvest of one family.

Results from the research log from July to December 2021, show that the families felt satisfied and happy with the study and with what they have done. Overall, the families had a personal perception of having more physical energy with better mood and health. Sometimes they felt disappointed when pests affected the plants which are common. Regarding the structure of the beds, there were two ruptures in the fabric; the research team is currently working on ways to prevent and solve this problem. Currently (April 2022) the families are still using the urban raised beds. Some comments about the experience from 4 of the 5 families are summarized in Table I.

TABLE I. RESEARCH LOG SEPTEMBER 2021

Name	Week 1	Week 3
Family 1 (La Cebada)	No problems reported. Crops: lettuce and spinach. Notes: New Zealand spinach has already spread over the whole garden, so she has to prune it constantly.	No problems reported. Crops: radishes, lettuce, epazote and spinach. Cooking: lettuce and epazote to complement pozole, spinach was used for a noodle soup and epazote to spice up other dishes. Pests: white flea Pest remedy: mixture of water, soap and garlic. Notes: Samantha says that having a garden has served as therapy in the last week, it makes her happy to see positive changes in her plants.
Family 2 (Peña Blanca)	Notes: She planted lettuce, tomato, radish, oregano, spinach, onion, chives, epazote and broccoli in her garden. Cooking: spinach soup and lettuce for salads.	Pests: on tomatoes Remedy for the pest: Mixture of garlic in water and salt.
Family 3 (Tecolalco)	Crops: Radishes Notes: Lettuce has grown, tomatoes are bearing fruit, oregano is sprouting, and new radishes have been planted. The spinach has been pruned, the thyme has dried up and the epazote is growing well.	Crops: None Pests: aphid on tomatoes Remedy for pest: not specified Notes: They started having problems with the harvest of several plants such as New Zealand spinach and garlic because they dried out. The chives never grew and were removed to plant carrots.
Family 4 (Santa Fe)	No problems reported. Crops: lettuce, radishes, epazote and chives. Cooking: Salads, mushroom soup with epazote and chives with egg and potatoes. Notes: She commented that the epazote had a very strong flavor.	Crops: lettuce, epazote, chives and thyme. Cooking: has used epazote, chives and thyme to spice up her dishes. Raised bed structure: It suffered a break in the tarp that holds soil. Pests: identified snails and red aphid. Pest remedy: she is using eggshell to treat the snail pest. Notes: she mentioned that in the last week she has felt happy and upbeat.

Six months after the distribution of the raised bed vegetable gardens, the families involved in the study had collected and consumed at a daily basis at least three ingredients to prepare their meals oriented to support their immune system, using either their own recipes or the ones provided with the e-cookbook. There has been no desertion of any family.

Figure 9. Raised bed vegetable garden with harvest.

As a summary, to show the results all together, the researchers share the following video: https://www.youtube.com/watch?v=L5DYAzmePek&ab_channel=MirandaOriOrlansino.

IV. DISCUSSION

The results show the viability of the proposal designed by the HI team as the urban cultivation of the proposed palette was achieved by the families in the study, considering the necessary strategies for a successful harvest. The feasibility of a home raised bed vegetable garden with dimensions of 109×80×30 cm (large bed) and 80×53×30 (small bed) with 10 plants per cycle; and in house containers one floral species, 1 tuber, and 2 aromatic herbs were included per cycle. The educational accompaniment with videos, manuals and booklets proved to be helpful for the assembly of the raised bed structure as well as for the cultivation of the plant species proposed which were accomplished to grow and harvest. The development and distribution of the recipe e-cookbook promoted the incorporation of different vegetables into the family diet, supporting immunonutrition.

V. CONCLUSION

The knowledge, experience and expertise of the HI research team were essential to integrate all the elements into the project of the design and creation of family raised bed urban gardens. Derived from the results, the alternative of home gardens that provide a variety of easy to grow plant species in urban microclimates opens the possibility to extend the project and be tested in various areas of Mexico City in further studies.

Promoting a sustainable culture taking advantage of new technologies and virtual education (e-learning) is essential in developing theoretical and practical knowledge around the design and maintenance of family gardens, which helps to guarantee their use and endurance.

Urban gardens can promote a more direct connection between the inhabitants of a city and the food of daily consumption. They serve as productive, demonstrative, learning and recreational spaces, oriented towards environmental education. Additionally, urban gardens offer health benefits, increasing the quantity and high-quality of fresh food and products available to families.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

PMK carried out the immunonutrition research with the properties of each vegetable, designed the vegetable palette, and together with MRM prepared the scripts for the videos and educational materials, helped in the preparation of the videos and the e-cookbook; DAPDLM developed the raised bed design and materials' selection, prepared the booklet manual for its installation; MOO developed visual and audiovisual content creation, surveys, data collection and data analysis; EGHM conducted the surveys, data collection and data analysis; JMCP conducted the research and together with DAPDLM carried out field work with the families involved in the research; all together: paper draft; CAG style correction; all authors had approved the final version.

Funding

This work was supported by research funds of Universidad Iberoamericana Ciudad de México, through the grant INIAT #F145012 & DINVP #035.

Acknowledgment

The authors wish to thank A. Ma. Fernanda Sánchez Contreras, Social Service Program, Universidad Iberoamericana Ciudad de México; B. Marina Sil Acosta, Centro Ibero Meneses; C. Fernand Vedrenne-Gutiérrez, Health Department, Universidad Iberoamericana Ciudad de México; D. Elier Neri, DIQIA, Universidad Iberoamericana Ciudad de México; and E. Renata Rovelo Velázquez.

References

[1] B. Labatut and P. Figari. (April 2020). FAO offers 7 food tips to face the COVID-19 crisis and answers about its impact on food and agriculture (In Spanish). FAO Regional Office for Latin America and the Caribbean. [Online]. Available: http://www.fao.org/americas/noticias/ver/es/c/1268022/

[2] B. Zapatera, A. Prados, S. Gómez-Martínez, *et al.*, "Immunonutrition: Methodology and applications," *Nutrición Hospitalaria*, vol. 31, pp. 145–154, 2015.

[3] P. Calder. "Immunonutrition," *BMJ*, vol. 327, pp. 117–118, 2003.

[4] R. Grimble, "Basics in clinical nutrition: Immunonutrition – Nutrients which influence immunity: Effect and mechanism of action," *E-SPEN, the European e-Journal of Clinical Nutrition and Metabolism*, vol. 4, pp. e10–e13, 2009. doi:10.1016/j.eclnm.2008.07.015

[5] M. A. Murga-Menoyo. "Computer networks and environmental education," in *Globalization, Environmental Crisis and Education*, M. Aguirre, 1st ed., Madrid, Spain: General Sub-directorate for Information and Publications, 2002, pp. 169–201. (in Spanish)

[6] S. Corbetta, P. Sessano, and M. Krasmanski, "Environmental Education (EA), teacher training and ICT's, the complex challenge of a triple articulation. Towards the definition of a transversal space," *Magazine of the School of Sciences of Education*, vol. 7, pp. 267–290, 2012. (in Spanish)

[7] S. Diamond and B. Irwin, "Using e-learning for student sustainability literacy: Framework and review," *International Journal of Sustainability in Higher Education*, vol. 14, no. 4, pp. 338–348, 2013.

[8] S. Altomonte, B. Logan, M. Feisst, *et al.*, "Interactive and situated learning in education for sustainability," *International Journal of Sustainability in Higher Education*, vol. 17, no. 3, pp. 417–443, 2016.

[9] F. D. Barriga-Arceo, "Situated teaching: Link between school and life," 1st ed., México: Mc Graw-Hill, 2005. (in Spanish)

[10] L. G. Aretio. "Need for digital education in a digital world," *Ibero-American Journal of Distance Education*, vol. 22, no. 2, 2019. (preprint version, in Spanish). doi: http://dx.doi.org/10.5944/ried.22.2.23911

[11] J. R. Backs, J. Dawson, and W. Jarrell. "Urban greening: A case study to determine the efficacy of using low maintenance planters as a means of growing plants in Chicago urban settings," *Journal of Environmental Horticulture*, vol. 1, pp. 145–152, 2013.

[12] B. Penzenstadler, J. Plojo, M. Sanchez, *et al.*, "The affordable DIY resilient smart garden kit," in *Proc Workshop on Computing within Limits (LIMITS '18)*, 2018, pp. 1–10.

[13] E. J. Schifman, "Window mounted planter box," U.S. Patent 3946522, March 30, 1976.

[14] Y. C. Ciang and H. Chen, "Planting box device," U.S. Patent 2015/0201563 A1, February 21, 2015.

[15] F. J. Burmann, "Detachable and collapsible planter box being of a pallet box assembly," U.S. Patent 9655307 B2, May 23, 2017.

[16] J. Jeavons, *Biointensive Food Cultivation, More Food in Less Space (in Spanish)*, 6th ed, USA, 2002.

[17] Vegetable cultivation (in Spanish). (2020). [Online]. Available: https://odepa.gob.cl/handle/20.500.12650/53906

[18] (2012). Tree art and culture for evolution (in Spanish). Manual de Agricultura Urbana. Azoteas Verdes de Guadalajara. Guadalajara, Jal, México. [Online]. Available: https://blogdeazoteasverdes.wordpress.com/category/galeria/

[19] Farming concrete. (August 2015). Data collection toolkit. Methods for measuring the outcomes and impacts of community gardens and urban farms. A project of Design Trust for Public Space. [Online]. Available: https://farmingconcrete.org/barn/static/resources/DataCollectionToolkit.pdf

[20] Recommendations on growing food using recyclable and/or commonly used materials. Local food production (in Spanish). (2020). Universidad de Chile. [Online]. pp. 1–21. Available: https://libros.uchile.cl/files/presses/1/monographs/1102/submission/proof/8/index.html

Patricia Mehner-Karam B.Sc. degree in Medical Doctor (Universidad Anáhuac, Mexico City, México) 1996. Master in Applied Nutrition (Universidad Iberoamericana Ciudad de México, Mexico City, México), 2016.

She is certified as a Primary Care Physician, and certified as Diabetes Educator since 2003, also certified as Obesity and Comorbidities Specialist by SCOPE (World Obesity Federation) since 2019. She has been in clinical practice in the private sector at Hospital Español de México for more than 20 years. Academic for more than 25 years, full-time professor at the Health Department, Universidad Iberoamericana, Ciudad de México (Ibero) since 2019. She is the head of two postgraduate programs at Ibero: Obesity and Comorbidities Specialty and Diabetes Educator Diploma.

MD Mehner-Karam is a member of the Professional Section of the American Diabetes Association (ADA), member of the Association of Diabetes Care & Education Specialists (ADCES) and member of Mexican Diabetes Federation. Her current research interests and work includes MINOBES® (Modelo de Atención Integral para la Obesidad y el Sobrepeso), nutritional interventions in amputee population with or without diabetes, and nutrition & sustainability at Huerto Ibero, José de Acosta, S.J. Fully convinced that health depends on food and nutrition for either prevention and disease treatment.

Cesar A. Gutierrez received B.Sc. degree in biochemical engineering (Universidad Autónoma de Aguascalientes) in 2007; M.Sc. in Chemical Engineering (Universidad Iberoamericana Ciudad de México, Mexico City) in 2017.
He is currently a Ph.D. candidate in engineering sciences at the Universidad Iberoamericana Ciudad de México. He is a professor at the Department of Chemical, Industrial and Food Engineering at the Universidad Iberoamericana, in food process engineering and technology area.

Juan M. Casillas Pintor received B.Sc. degree in Architecture (Universidad Iberoamericana Ciudad de México) Mexico City in 2001; Master in Sustainable Design, Architecture and Construction, (Universidad del Medio Ambiente) Valle de Bravo, México in 2007.
He is a full-time professor at the Architecture Department in Universidad Iberoamericana, Ciudad de México, oriented towards regenerative advocacy projects through education, design and implementation of appropriate solutions. He has more than 20 years of professional experience in the area of design, natural building and social impact projects.

Miranda Ori-Orlansino received B.Sc. in Chemical Engineering (Universidad Iberoamericana Ciudad de México, Mexico City, Mexico) in 2021.
She is a Research Assistant at Instituto de Investigación Aplicada y Tecnología (INIAT) from the Universidad Iberoamericana Ciudad de México. She is currently in charge of Huerto José de Acosta S.J. at Universidad Iberoamericana Ciudad de México. She was an intern for six months at Italcer S.A de C.V in the purchasing and innovation departments in 2021.

Daniel A. Perez-DeLaMora received B.Sc. in Mechanical and Electrical Engineering (Universidad Iberoamericana, Ciudad de México, Mexico City, Mexico) in 2008; M.Sc. in Industrial Design Engineering (Delft University of Technology, Delft, Netherlands) in 2013.
He is an Academic Technician at the Institute of Applied Research and Technology (INIAT), Universidad Iberoamericana Ciudad de México. He is currently a Ph.D. candidate in Engineering Sciences at the Universidad Iberoamericana. He is an independent consultant in Renewable Energy and Energy Efficiency. He has been teaching at the Universidad Iberoamericana since 2014. He has a published journal paper in the area of renewable energy.
M.Sc. Perez-DeLaMora is a member of the Mechanical and Electrical Engineering Advisory Board of the Universidad Iberoamericana.

Mariana Ruiz-Morales received B.Sc. in industrial engineering (Universidad Autónoma Metropolitana, Mexico City, México) in 1993; Master of Engineering (agricultural and biological engineering) (Cornell University, Ithaca NY, USA) in 1996; Ph.D. in human development (Universidad Iberoamericana Ciudad de México, Mexico City, Mexico) in 2004.
She has been a full-time professor since July 2000 at the Engineering Department, Universidad Iberoamericana Ciudad de México, Mexico. Courses lectured: Simulation, Industrial Ecology, Introduction to Industrial Engineering. She was the head of the Industrial Engineering Program from March 2016 to March 2018. She has several publications in the areas of sustainability, solid waste management, and urban gardens, and she has been a speaker in international conferences in Portugal, South Africa, and the United States.
Dr. Ruiz-Morales is a lifetime member of the Cornell Engineering Alumni Association and is a member of the editorial board of the American Journal of Environmental Engineering.

Eduardo G. Hernandez-Martinez received B.Sc. in Electronics engineering (Instituto Tecnológico de Orizaba, Orizaba, México) in 2003; M.Sc. and Ph.D. Electrical engineering (mechatronics) (Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional CINVESTAV-IPN, Mexico City, Mexico) in 2005 and 2009, respectively.
He was a full-time professor from September 2011 to October 2018 at the Engineering Department, Universidad Iberoamericana Ciudad de México. Courses lectured: Control engineering, Automation, Mobile robotics. Nowadays, he is the head of the Institute of Applied Research and Technology (INIAT) since November 2018. He has published journal and conference papers in the areas of mobile robotics, control systems, and automation.
Dr. Hernandez-Martinez has been a member of the Institute of Electrical and Electronics Engineering (IEEE) and the International Society of Automation (ISA).