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INNOVACIÓN EDUCATIVA EN EDIFICACIÓN

What do we know about sustainable construction? The importance to learn from the global knowledge. The Venezuelan case

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HIGHLIGHTS

- The construction sector faces essential challenges and complexities. This demand its actors to be prepared to confront them.
- Sustainable construction offers resources to challenge such complexities and build long-term solutions for all.
- Considerable knowledge comes from previous learnings, successes, and failures that can enrich construction education and decision-making.
- The architecture and engineering academic curriculums evaluated in the current research show a wide range of approaches to education from only technical to sustainable-integral perspectives.
- Can construction education benefit from the existing global knowledge, aligning theory and practice? What can we learn from the Venezuelan case to enrich our construction learning and improve sectoral competitiveness?

ABSTRACT

Construction stakeholders plan to guarantee the success of projects. Still, the results frequently are different in quality, time, or costs. The disruptions are frequent, and the stakeholders must be ready to react promptly to changes while keeping competitiveness and sustainability. This goal requires proper construction education. Based on diverse civil engineering and architecture programs, the article evaluates if current construction education includes past knowledge, notions of sustainability, and global matters to allow its participants to identify challenges and risks, giving them the tools to act appropriately. The results show different construction education perspectives. Some are very advanced, and others are not. The Venezuelan case is a reference to link theory and practice in the construction sector. Incorporating critical analysis and comparisons with data and cases from diverse successes, disruptions, or errors is presented as education innovation to support this industry's competitiveness and sustainability.

Keywords: *Sustainability, Construction, Covid-19, Venezuela, Education Innovation*

1. INTRODUCTION

There is a large amount of information regarding the importance of improving education as a fundamental element of enhancing sustainability. The United Nations declared Quality Education the 4th Development Goal to be accomplished [1].

In a complementary perspective, in their statement of sustainability [2], the European Student Union highlighted the importance of studying sustainability holistically, going much forward to the climate and sustainable development goals to include all its different dimensions. For this reason, they urge to see all sustainability variables, including the creation of an added valued education to back new sustainable ecological, environmental, political, economic, production, and consumer attitudes from all the population. The aim is that such education becomes the basis for balanced, sustainable communities living with social justice. They highlight the necessity for all the government and policymakers, educational institutions, and companies to act to sustain the implementation of sustainability. They stress that many people are still not yet involved with these processes, and thus, the educational environment has great capacity and need for changes to become an active part of the sustainability struggles. Additional efforts are necessary for all the alumni to be prepared with the knowledge and competencies required to support the sustainable changes necessary [2].

Because of such relevance, diverse groups declare the importance of education explicitly, affecting all global activities and our future. Regarding the construction environment, the American Society for Engineering Education (ASEE) generated a statement on Sustainable Development Education [3]. They established the necessity of providing engineering students with a comprehensive educational curriculum that would fully prepare them to understand and support sustainable development. This requires an integral education that includes ethics, understanding other nations, and cultures, and forming interdisciplinary teams to study sustainable engineering design and construction techniques, systems, clean technologies, economies, and their global interconnection. They also propose incorporating case studies and evaluating the relationship between society, environment, and engineering to see how they can act together to make viable and usable sustainability concepts and policies. Likewise, this will help engineering students and related parties use such knowledge in their corresponding communities to support their evolution into a global perspective.

To determine the main areas of attention in construction education, Wang [4] also studied the importance of incorporating sustainability into engineering teaching. This author sustains that sustainability issues must be included in all engineering knowledge areas and all stages of education. This means that theoretical content, course planning, techniques, construction management programs, and evaluation of lessons learned must be performed within the sustainability framework to achieve continuous improvements in the construction industry. This goal demands essential changes in the traditional construction and management paradigm, the revision of education methodology and content, and the development of adequate education for educators, students, and all related parties to make them sensitive to support the changes needed to promote genuinely sustainable education and become part of the solutions.

The interest in reaching this goal extends in various environments to the point that specialized studies have been developed on the subject. The studies focus on developing the sectoral participants' potential and making innovative changes to improve the building's environmental performance through sustainable design and operations. These results can be achieved by an integral virtuous circle that enables the optimization of the use of water, energy, and materials, minimizes waste, reduces the carbon footprint, and at the same time values and enriches the history, art, and anthropological heritage of humanity [5, 6].

Such a framework makes the construction industry struggle to keep evolving, become global, competitive, sustainable, and change quickly to overcome disruptions, challenges, and new realities. Given the importance assigned to quality education in architecture and engineering, it calls for reflection on the frequency of construction problems that lead to performances different from the ones planned initially in terms of time required to complete the project, budget invested, or final quality.
This approach shows that the reality and complexity of construction problems and their challenges and uncertainties sometimes exceed the preparation of experts and that the advances in implementing sustainability are not progressing at the expected pace.

In part, understandably, this happens due to the complexity of construction and the political, socio-economic challenges, and uncertainties that often offer unexpected circumstances that affect projects' performance, as the COVID-19 pandemic showed.

As current challenges can no longer be addressed only with traditional strategies, construction stakeholders are suggested to act according to such new circumstances to incorporate some other existing knowledge that may reduce the risks of changes in construction results.

With this aim, the authors question. What do we know about sustainable construction? Are we benefiting from the global learning accumulated in this sector?

Thus, the research is oriented to reflect if the current construction education takes good advantage of the existing knowledge related to the complexity of construction, its history and antecedents, the principles of sustainable construction, the opportunities and current risks, and the resulting lessons from global construction successes, mistakes or failures.

The article introduces the Venezuelan case to identify whether construction education can be enriched with additional learning from recent experiences. From such a perspective, the authors present data about the consequences that Venezuela suffers for not following the sustainable path, which may be found in the delays and cost overrun of infrastructure projects, competitiveness loss, deterioration of quality of life, and increase in inequality, and poverty levels among others.

Then a question arises. Is the knowledge, either ancient or from cases like the Venezuelan, used by experts to avoid similar problems in the future? Or is the construction industry frequently

stumbling over the same stone without getting enough of the knowledge acquired?

To promote positive changes, the goal is to include in construction education a critical review to allow individuals to go beyond their local perspectives and enrich their decision-making with a global view based on incorporating other non-traditional learning and the anticipation of opportunities and risks.

Expanding the construction perspective, incorporating critical analysis and comparisons with data of diverse global cases, may become an education innovation with added value to enrich the construction industry. Having actors more aware of the reality surrounding them may support the increase in competitiveness and sustainability of this vital industry, obtaining better construction performances.

2. SOME ANCIENT AND CURRENT KNOWLEDGE AVAILABLE. DO WE TAKE ADVANTAGE OF THEM?

It is generally accepted that science evolves from previous knowledge. It happens with the construction environment. Much knowledge from our building ancestors or current construction challenges should be used as references to enrich other processes.

Does that happen like this? Do we take advantage of our ancient learning and the successes and mistakes of the present in a comprehensive way?

To introduce such reflections, the authors summarize some antiquity lessons from architecture and construction sectors that highlight the vital knowledge that comes from the past. See Tables 1 and 2.

Table 1: *Some antiquity lessons- Architecture teaching*

Place/ Culture	Remarks-Period	Main Subjects related to sustainability & global issues	Source
Architect Marco Vitruvio Pollione Roman Empire, Italy	1. Century BC. Roman architect, writer, engineer. Author of "De architectura". Oldest architecture text preserved.	Architecture composed by: the Ordination, the disposition, the eurythmy, the symmetry, the ornament, and the distribution or economy. Importance of environmental considerations.	[7] De architectura. Marco Lucio Vitruvio Pollione
European Architecture, Reinassance period, Europe	15th-16th Century AC	Architects began to systematically study the shaping of urban space/ Cities piece of architecture with aesthetically pleasing and functional order.	[8] History Of Cities And City Planning. Cliff Ellis

Table 2: *Some antiquity lessons- Construction*

Place/ Culture	Remarks-Period	Main Subjects related to sustainability & global issues	Source
Caral-Supe Ancient city of Caral-Supe. Caral civilization, Peru	Founded 30th century BC- abandoned 18th century BC. Late archaic period. Oldest prehispanic American civilization. Central Andes	Model of sustainable living/ Innovation: Flexible foundations "shicras" to stabilize structures/ Underground ductsMessage: Society should respect the environment	[9] Role Modeling Sustainable Living through the Ancient City of Caral-Supe 2015
Derinkuyuin, Turkey	8th century BC	Underground citiy: Tunnels and rooms beneath homes (scaved in vulcanic rock). To protect from war and natural disasters	[10] Architecture: Impressive, Imperishable and Inimitable
Ercolano and Pompei, Gulf of Napoli. Roman Empire, Italy	Ercolano: Founded 12th century BC Pompei: Founded IX Century BC. Both destroyed by eruption of Vesuvio vulcan 79 AD. Ercolano. One of best roman archeological site. Preserved under volcanic ash & pumice	Use of sustainable products & techniques. Some features: Indoor comfort with air flow and optimum light. Sky-lights. Floors as reflectant of natural light. Roof to lower heat and capture rainwater/ Streets system sloped to allow open sewage by gravity. Bath houses.	[11] Archeomania. Video: HERCULANO Practicas de construccion sostenible
Great Dam, Yemen	750 BC	Dam stoof for over 1.000 years. Converted Yemen into a Fertile oasis (Kingdom of Sheba)	[10] Architecture: Impressive, Imperishable and Inimitable
Great Piramid of Giza, Egypt,	The oldest and largest of the three pyramida in the Giza Complex.	Vast and advanced knowledge: geophysics, geography, astronomy, geography, engineering and architecture. Art & Architecture represents the belief in life after death & veneration of the gods. Stone and mud brick	[10] Architecture: Impressive, Imperishable and Inimitable
Mesa Verde Colorado Dwellings, USA	80Th Century BC (nomadic Paleo-Indians). Ancestral puebloans. Best-preserved Ancestral Puebloan archaeological sites in USA	Dwelling below cliff hanging. Homes below and farming the land in the top. natural climate control, protection from invasions	[10] Architecture: Impressive, Imperishable and Inimitable
Mud Houses, India	18th century AC	Kachchegar Mud houses. Natural cooling conditions. Designed as form following function principle.	[10] Architecture: Impressive, Imperishable and Inimitable
The ancient Mayan city of Tikal, Guatemala	Founded 3th century BC- disappeared X century	Water reservoirs and canals/ Stored rainwater. Excavation and paving of gullies to prevent water absotion. Water directed into the reservoirs. Elaborated systems of water storage and distribution. Agriculture on terraced land	[12] A Lesson in sustainability from ancient cities

Figure 1. L. da Vinci Cranes. Museo Leonardiano, Vinci, Italy

Figure 2. Jaguar temple, Tikal, Guatemala

The references presented show a brief summary of the many comprehensive fundamental lessons from antiquity. Such fundaments should be embedded in all the stages of the construction education from the early years of study to enable the formation of construction participants with an integral and broad perspective aware of the value of ancient learnings along with the opportunities, risks, and learning present in every epoch.

As a complement, in the following tables, 3 through 8, the authors present a compilation of some of the current knowledge available for the construction stakeholders for diverse specialty areas.

Table 3 *Some available knowledge*

Quality, Environment and Health international Standards and data		
Source	**Description**	**Contributions and data provided**
ISO 9001 Standards	Quality Management System	Practical and workable Quality Management System for improving and monitoring all areas of business.
ISO 14000 Standards	Environmental Management System	Standards to promote effective environmental management systems in organizations. Provide cost-effective tools that make use of best practices for organizing and applying information about environmental management.
ISO 45000 Standards	Occupational Risk Prevention Management System	Enables the organisation to improve their occupational health and safety performance in preventing injury and ill-health.
OHSAS 18001 Standards	British standard for occupational health and safety management	Tool that provides a guide for an organization to implement and evaluate itself in relation to its occupational health and safety procedures.
OSHA		National Emphasis Program (NEP) – Coronavirus Disease 2019 (COVID-19).
ISO 37001 Standards	Anti-bribery management systems	Guidance for establishing, implementing, maintaining, reviewing, and improving an anti-bribery management system.

Table 4: *Some available knowledge*

Health statistics and data	
Source	**Contributions and data provided**
World Health Organization Data Platform	Official WHO health statistics. Provides easy access to health-related data for all 194 Member States. Monitores global, regional and country trends.
Johns Hopkins Data Management Services	Provides researchers guidance on data management planning and archives JHU research
COVID-19 Response for disaster Risk Management	Lessons Learned from COVID-19 response for disaster risk management

Table 5: *Some available knowledge*

Finance, accounting and Assurance	
Source	**Contributions and data provided**
IAS: International Accounting Standards (IAS)/ International Financial Reporting Standards (IFRS)	Set of common rules so that financial statements can be consistent, transparent, and comparable around the world. International Accounting Standards (IAS): Older accounting standards issued by the International Accounting Standards Board (IASB). Were replaced in 2001 by International Financial Reporting Standards (IFRS)
International auditing and Assurance Standards	(IAASB) Independent standard-setting body. Set high-quality international standards for auditing, quality control, review, other assurance, and related services. Strengthen public confidence in the global profession.

Table 6: *Some available knowledge*

Infrastructure and construction	
Source	**Contributions and data provided**
The GMP P5 Standard for Sustainability in Project Management	Promote the application of sustainability principles (P5) in product, process, people environment & prosperity (economics) project variables. Integration of sustainability principles in Project Management
MSCI World Infrastructure Index (USD	Captures the global opportunity set of companies that are owners or operators of infrastructure assets. Constituents are selected from the equity universe of MSCI World, the parent index, which covers mid and large cap securities across the 23 Developed Markets (DM) countries. All index are categorized in one of thirteen sub-industries according to the Global Industry Classification Standard (GICS®), which MSCI then aggregat
New Global Index of Infrastructure: Construction, Rankings and Applications	Comprehensive and comparable indices on the most relevant components of economic infrastructure. Cover the largest possible number of developing and developed countries over the period 1990-2010. Map major findings from the new indices of infrastructure and provide country rankings, which also compare with subjective assessments of infrastructure in the World Economic Forum's Global Competitiveness Rep
Global Country Ranking Infrastructure quality	Ranking of countries according to their general quality of infrastructure
COVID-19 and the Global Construction Busines	Set of data and learning related to the effects of Covid-19 on the construction business. Strategies to transform the Covid-19 from severe disruption to improvement opportunity for the construction industry.

Table 7: *Some available knowledge*

Competitiveness & Sustainability	
Source	**Contributions and data provided**
Company information, data and statistics	Company data regarding finance, production, labor, projects, quality, equipments, human resources, social processes, environment, relations with value chain, sustainability, opportunities and risks
CPI. Corruption Perception Index	Published by Berlin Transparency International since 1995. Ranks countries by their perceived levels of public sector corruption, as determined by expert assessments and opinion surveys. Defines corruption as the misuse of public power for private benefit
Countries national and sectoral statistics	National and sectoral statistics of economy, production, labor, financial sector, population, quality of life, public services, infrastructure, environment, sustainability, oppofrtunities and risks
ESG Index. Environmental, social, and governance Index	Offers investors exposure to companies according to their ESG profile. Provide a benchmark of companies exhibiting best corporate social responsibility practices. Track the performance of companies with superior ESG index ratings for environmental, social, and governance practices.
Global Competitiveness Index (WEF)	Report ranks countries based on the Global Competitiveness Index. integrates the macroeconomic and the micro/business aspects of competitiveness into a single index.The report assesses the ability of countries to provide high levels of prosperity to their citizens.
Spillover Index	Assesses spillovers along four dimensions: environmental, economy & finance, social and security.
Sustainability indices	Stock market indices that evaluate the sustainability performance of companies. Synthesize concepts related with general company sustainability.
SDG. Sustainable Development Goals Index	Report twhere each country stands with regard to achieving the Sustainable Development Goals (SDGs). Set standards for all the nations.
DJSI. Dow Jones Sustainability Index	Set of various sustainability indices. Tracks the stock performance of the world's leading companies in terms of economic, environmental and social criteria. Integrate companies listed in the stock market with high performance in different areas such as economic, social and environmental. Comprises global, regional, and country benchmarks
WDI. World Bank Indicators	World Bank's premier selection of cross-country comparable data on development. Is a compilation of relevant, high-quality, and internationally comparable statistics about global development and the fight against poverty.

Table 8: *Some available knowledge*

Domotics Robotics Smart Cities	
Source	**Contributions and data provided**
Domotics	Home automation. Implies the control of domestic appliances by electronically controlled systems
Robotics	Interdisciplinary field that integrates computer science and engineering. Involves design, construction, operation, and use of robots.
Smart cities	Cities that uses technology to provide services and solve city problems. Improve transportation and accessibility, improve social services, promote sustainability, and give its citizens a voice.

The compilation of some of the antiquity and current knowledge presented pretends to reflect whether the construction participants know the interdependence and complexity of the multidisciplinary activities involved in every small or big project and the fragile balance that sustains it.

It suggests the importance of evaluating if the current construction education prepares educators and students with a critical and proactive approach in front of all the variables from the past and the global environment in which we operate. It implies that all must see what is happening, foresee coming changes, and then adapt.

This integral perception may help the construction participants be capable of acting correctly in this complex, changing world with unforeseen events and thus support the achievement of the best sustainable results of every project.

3. WHAT DO THE ENGINEERING AND ARCHITECTURE CAREER PROGRAMS SHOW?

To make a preliminary evaluation of the academic and practical content enclosed in current construction education, the authors reviewed some of the architecture and civil engineering programs accessible in different countries. The revision was made only based on the available basic information at the WEB for some randomly selected universities and did not pretend to demonstrate in-depth the scope, content, or quality of such university degrees.

The data include the revision of 25 programs for 19 Universities. 2 are located in Africa, 5 in Asia, 2 in Europe, 1 in Oceania, 1 in Russia, 2 in the United States, and 6 in Latin America.

The inclusion of more programs for this last region arises from selecting the Venezuelan case as a research reference due to the infrastructure and competitiveness problems that the country confronts.

The revision aims to determine if the current study programs and curricula mention sustainable or global study topics that may help students and professors develop critical analysis and motivate them to build new learning based on previous or related knowledge. Furthermore, the study wishes to verify if the curricula promote understanding of the current challenges, complexities, and realities of the global construction industry, the significance of including sustainability issues in all construction and personal activities, and the consequences in case such suggestions are not fulfilled.

Tables 9 through 15 present a brief reference of the topics found in each study program and

curricula that the authors consider could motivate the critical analysis and attitudinal changes desired. The tables also mention the cases in which the curricula do not include any particular subject of sustainability or global issues.

Table 9 *Sustainability and global issues on Architecture and Civil Enginnering programs Africa*

University, Country	Career/program	Main Subjects related to sustainability or global issues	Subjects not specifically mentioned
University of Johannesburg, South Africa	Engineering and the Built Environment	Global education, Sustainable development goals, Fourth industrial revolution (digital, biological, physical, emotional & social technologies). Technologies and innovative business models/ Sustainability	
	Art Designe and Architecture	Competitiveness, Changes occurring in the world of Art & Design. Theoretical and social Aspects of Architecture. Shaping the Built Environment (Low Rise To Multi Level Private Projects).	Sustainability/ Global Development Goals
University of Nigeria, Nsukka	Civil Engineering	Concepts and theories of peace and conflicts/ Logic/ Philosophy and human existence/ Peace & conflic resolution studies/ Nigerian people and cultures	Sustainability/ Global Development Goals

Table 10: *Sustainability and global issues on Architecture and Civil Enginnering programs Asia*

University	Career/program	Main Subjects related to sustainability or global issues	Subjects not specifically mentioned
Korea University of Technology and Education, Korea	Architecture and Architectural Engineering	History of architecture/ Theory of criticism of architecture/ Building environmental technology/ Energy conservation/ Context of the culture and city relationship & society/ Environment	Sustainability/ Global Development Goals
Jadavpur University, Kolkata, India	Architecture	Community outreach programs/ Societal services urban populations/ Leaders for human & just world/ Adhesion to Global Change Program	Sustainability/Global Development Goals
	Civil Engineering		
University of Ryukyus, Okinawa, Japan	Civil Engineering and architecture	Disaster prevention planning/ Urban & regional planning/Wind & Earthquake resistance engineering/ Coastal environmental Engineering	Sustainability/ Global Development Goals
Syiah Kuala University, Kuala Lumpur, Indonesia	Civil Engineering	Civic education/ Basic cultural and social sciences/ Environmental knowledge and disasters	Global Developmento Goals
Tianjin University, Tiajin, China	Architecture	Contemporary architecture/ Chinese & Foreign cities, History of art, design, urban construction, traditional and modern building/ Heritage protection	Sustainability/ Global Developmento Goals

Table 11 *Sustainability and global issues on Architecture and Civil Enginnering programs Europe*

University	Career/program	Main Subjects related to sustainability or global issues	Subjects not specifically mentioned
Universidad Politécnica de Madrid, Madrid, Spain	Double degree in Building and Business Administration and Management	History of construction/ Spanish, world & regional economy/ International markets / Innovation management / Strategic direction/ Pathology & rehabilitation/ Sustainable construction & auditing/ Risk management	
	Edificacions	Introduction to construction/ Company economics/ Construction history/ Universal accessibility applied to building/ Spanish popular construction/ Challenges in building/ History of urban law and planning of Madrid	Sustainability/ Global Development Goals
Universita Politecnica delle Marche, Ancona, Italy	Civil and Environmental Engineering	Environmental Health Engineering/ Building science	Sustainability/ Global Development Goals
	Architecture and Building Engineering	History of architecture/ Historical and special building systems/ Science and technology of traditional materials and degrade/ Vulnerability of historical Building/ Design for enhancement and conservation of architectural heritage	Sustainability/ Global Development Goals

Table 12 *Sustainability and global issues on Architecture and Civil Enginnering programs Oceania*

University	Career/program	Main Subjects related to sustainability or global issues	Subjects not specifically mentioned
University of Adelaide, Adelaide, Australia	Engineering Architectural and Structural	High tech building solutions/ Innovative infrastructures/ Sustainability & architectural integrity/ Renewable energy/ Sustainable housing/ Wind and earthquake/ Environment/ History	

Table 13 *Sustainability and global issues on Architecture and Civil Enginnering programs Russia*

University	Career/program	Main Subjects related to sustainability or global issues	Subjects not specifically mentioned
Peter the Great St. Petersburg Polytechnic University, St Peterburg, Russia	Civil Engineering	Methods & management models road construction/ Theory of risk/ engineering ecology/ Reliability, safety & cost effectiveness in Hydrotechnical Engenieering, Operating in difficult circumstances/ energy and resource efficiency/ waste management/ industrial and civil engineering in difficult ground conditions/ Urban infrastructure and housing and communal services	Sustainability/ Global Developmento Goals

Table 14 *Sustainability and global issues on Architecture and Civil Enginnering programs United States*

University	Career/program	Main Subjects related to sustainability or global issues	Subjects not specifically mentioned
Cornell University, New York, USA	Civil and Environmental Engineering	Complexity and globality of construction/Networks, Information systems/ Global and construction risks/ Sustainability/ Balance among constructed human environment and the natural world/ Business and regulatory arena	
Massachusett Institute of Technology (MIT), Boston, USA	Civil and Environmental Engineering	Sustainable tech/ Tools for sustainable design/ Sustainability/ Food/ Innovation/ Renewable energy/ Ecology	

Table 15: *Sustainability and global issues on Architecture and Civil Enginnering programs Latin America*

University	Career/program	Main Subjects related to sustainability or global issues	Subjects not specifically mentioned
Instituto Universitario Santiago Mariño, Maracaiy, Venezuela	Civil Engineering	Cultural formation/ Sysmic Engineering/ Ethics and Deontology	Sustainability/ Global Developmento Goals
Universidad Central de Venezuela, Caracas, Venezuela	Arquitectura y urbanismo	Architecture Theory/ Technology and Architecture/ History/ Human Settlements/ Environment & edifications	Sustainability/ Global Development Goals
Universidad del Zulia, Maracaibo, Venezuela	Ingenieria Civil	Way of life & national identity/ Ethics/ Water supply and liquid waste collection	Sustainability/ Global Development Goals
	Ingenieria Mecanica	None	History/ Sustainability/ Global Development Goals
Universidad Lisandro Alvarado, Barquisimeto, Venezuela	Ingenieria Civil	Comprehensive training/ Job orientation	Sustainability/ Global Development Goals
Universidad Rafael Urdaneta, Maracaibo, Venezuela	Facultad de Ingenieria Escuela de Arquitectura	History of architecture/ Introduction to architecture/ Deontology and professional practice/Architecture, ecology & Community service	Sustainability/ Global Development Goals
	Escuela de Ingenieria Civil	Engineering topis/ Introduction to Engineering/ Ecology & pollution/ Community service / Deontology	Sustainability/ Global Development Goals
Universidad de Cordoba, Cordoba, Argentina	Arquitectura, Urbanismo y Diseno	Introduction to history/ History	Sustainability/ Global Development Goals

Despite being the first approach to a question that deserves further studies, such programs' revision shows interesting facts.

Sustainability and Sustainable Development Goals are extended among several universities with various studies, including global and construction risk or operating under challenging circumstances. In others, they are not even mentioned.

There are cases where the emphasis is put only on the technical aspects of the career. Still, there are no links among them with the past teachings, the heritages of ancient learning, and the current lessons learned from the global economic, social, environmental, and cultural variables related to sustainability in such programs.

The preliminary revision also glimpses a shortage of critical analysis of projects, events that affect the world daily, and their bonding with the technical, sociological, economic, and political variables. Most Latin American programs lack specific references to sustainability issues and development goals. This situation requires a much deeper analysis.

4. THE VENEZUELAN TEACHING

To link the current study with cases that may become a source of important lessons learned, the authors present some data regarding the Venezuelan non-sustainable practices. Diverse national and international experts describe the case as unexpected in a country with vast resources that used to be an energy and modernity leader in Latin America.

The loss of Venezuelan leadership in the Latin American region occurred due to a structural crisis born more than two decades ago. The causes are multivariate and interconnected. Some may be found in the increase in the levels of state interventionism, the adaption of the legal framework to impose an autocratic political code, and the reshaping of the former thriving oil industry. The new socio-political-economic model avoids the technical and economic guidelines and meritocracy to respond mainly to political mandates. These facts, along with the abandonment of the construction and maintenance projects and the mismanagement of the public institutions, have led to weakened governance, extended corruption, and the progressive loss of quality of life and competitiveness [13].

Consequently, the country confronts severe increases in public debt, delinquency, scholar desertion, malnutrition, massive emigration, poverty levels, and a vast humanitarian crisis. Such complex conditions have worsened

because of the COVID-19 pandemic [14]. Some of such evidence is verified by eloquent indicators. For example, Table 16 shows the energy deficit in Venezuela caused by the failure to adhere to maintenance plans and fuel shortages.

Table 16 *Energy supply in Venezuela- MW Deficit*

Energy type	Installed capacity MW	Available capacity MW	Unavailable capacity MW	% of unavailability	Source
Thermal	17.6	6.5	11.1	63%	[15] Portillo 2019. Crisis electrica en Venezuela. [16] Portillo 2016. Servicios en crisis.
Hydropower	16.5	10	6.5	39%	
Total MW	34.1	16.5	17.6		

Table 17 shows another perspective of the infrastructure projects in Venezuela. Of the 15 hydro or thermoelectricity projects currently in development, only the Masparro Dam has been completed. The remaining projects are paralyzed or work only partially.

Table 17 *Venezuelan Main Electric Generation Projects Evolution – Hydropower*

Plant/Project type	Capacity MW	Project start date	Scheduled start-up	% of completion 2020 (Corpoelec)	% of completion 2020 (Experts)	Source
Simón Bolívar (GURI)/R	700 MW	2001	2014	35	35	[17] www.corpoelec.gob.ve/proyectos [18] Salas. 2018 Indagacion sobre el sector electrico en Venezuela
Manuel Piar (TOCOMA)/C	2160 MW	2002	2012/2014	66	66	
Fabricio Ojeda (La Vueltosa)/C	514 MW	2004	2010	72	72	
Antonio J. de Sucre	120 MW	2006	2014	44	44	
Masparro/C	25 MW	2005	2009	100	100	

Project type: R: Refurbishment. C: Construction

Several other indicators show that services and transportation infrastructure conditions in Venezuela are also insufficient. The lack of maintenance and investment spoils streets, bridges, ports, airports, or refineries. This situation has led to the loss of the advantages that Venezuela had with the logistics infrastructure and made it challenging to produce oil, derivates, gas, or other products. Additionally, it causes spills, water and electricity losses, and the accumulation of wastes that are not treated, with severe environmental damages [13, 14].

What does such data teach about Venezuela? It is evident that with the increase in poverty levels, the loss of freedom, and the damage to competitiveness, environment, and quality of life, the country is not following a sustainable path. The loss of direction of Venezuelan sustainability can be seen in the following graph.

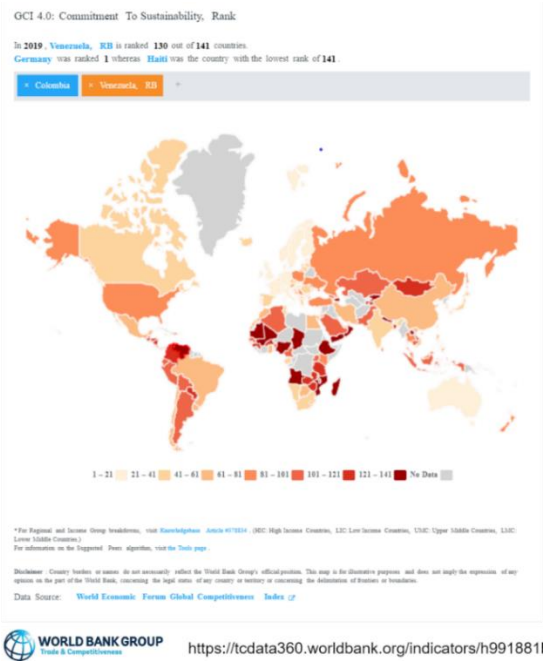

Figure 3: Venezuela. Commitment to sustainability. WB [19]

The Venezuelan lessons result sore because of severe consequences for the Venezuelan people and the rest of the world.

5. CONCLUSIONS

The current research is an introduction to a case that needs further study. As recognized by experts, the availability of vast amounts of global data, information, and knowledge does not necessarily mean that humanity can make the best profit from it. In effect, the added value of such resources is often lost. The volume of data, information, and knowledge and the lack of awareness on selecting and using what is best

for specific purposes are causes that limit their optimal use. This situation has forced more profound attention to developing different techniques to manage such resources and the quality of education, including the educational content and the teaching/learning processes.

These arguments also apply to construction. With more than 220 million people working in the construction sector worldwide in 2019 [20] and an essential part of the global wealth depending on the sectoral performance, paying attention to construction education is necessary. The construction industry manages massive intangible resources. Some are tacit, and some are explicit, but most are valuable for industry performance. So, it is necessary to determine if the content of construction educational programs and the approach given to teach them may optimize their results.

For this purpose, the current research evaluated some basic ideas about the available knowledge resources. Some originated in ancient times from the history of construction, engineering, and architecture. Others are from recent times. Both are needed to see whether they are used to support the sustainability efforts in the construction sector and improve its performance. To do so, the researchers revised the career programs for some civil engineering and architecture faculties in a sample of universities worldwide. This revision was performed to identify whether they include sufficient learnings from history, sustainability, and global knowledge.

Not only because of the regional differences, but the findings show that the engineering and architecture programs revised differ significantly. Some of them are complete. They propose an integral construction teaching perspective that may allow the participants to enrich their decision-making. Including learning from past and present and their critical review seems to add value to the industry. However, some other programs hardly mention sustainability or not at all. In some cases, they neither propose to link the theory with what happens in the global construction world.

The authors introduced the Venezuelan case as a matter of reflection related to such different educational approaches. The data presented explain the competitiveness loss, the deterioration of the quality of life, and the increased poverty levels accumulated in the last two decades in Venezuela for not considering sustainability among other structural problems. This situation is an example of what we can learn from textbooks and the web, mainly from the reality surrounding us.

The authors highlight the necessity for construction education to select and use the available data, information, and knowledge appropriately. This approach needs to be mandatory to take their best chance. Expanding the construction perspective by incorporating critical analysis and comparisons with data and cases from diverse successes, disruptions, or mistakes may become an education innovation with added value to enrich the construction industry. Having actors more aware of the reality surrounding them may support the increase in competitiveness and sustainability of this vital industry, obtaining better construction performances.

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