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Journal of Technical Education

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The works must be unpublished and refer to topics of Evaluation, teaching and teaching, learning and development of cognitive processes, planning for the potentializing of learning, Development of competencies through expected learning and other topics related to Humanities and Behavioral Sciences.

Presentation of the Content

In the first article we present *Development of new standardized methods for calculating fuel poverty index: a study in the coast of Cabo Corrientes Jalisco*, by Cerda-Carrillo, Nely, Vega-Gómez, Carlos Jesahel, Sandoval-Hernández Erika and Rojas-Ramírez, José Juan Pablo, with adscription in the Universidad de Guadalajara, second article we present *Facing the gap: Digital villages for life transformation small and medium enterprises in Morelos*, by Juárez-Salomo, Norma Angélica, Silveyra-Rosales, Mariana Teresa, Cuevas-Olascoaga, Miguel Ángel and Gama-Hernández, Gerardo with adscription in the Universidad Autónoma del Estado de Morelos, next article *Supported learning in STEAM and PBL methodology; Using 3D CAD Software for the mechanical design of sumo robot*, by Peña-Montes De Oca, Adriana Isela, Gallardo-De La Rocha, Alfonso and Hernández-Hernández, Adriana Janette, from the Universidad Tecnológica de Jalisco, as fourth article we present *Proposal for student entry profile into software projects under the ISO/IEC 29110 standard*, by Arredondo-Salcedo, Daniel, Salas-Guzmán, Manuel Ignacio and García-Molina, Yolanda Meredith, with adscription in the Instituto Tecnológico Superior Zacatecas Norte, as next article we present *Measurement of refractive index in liquid mixtures using Interferometry*, by López-Álvarez, Yadira Fabiola, Peña-Lecona, Francisco Gerardo, Jara-Ruiz, Ricardo and Rodríguez-Franco, Martín Eduardo, with adscription in the Universidad Tecnológica del Norte de Aguascalientes and Universidad de Guadalajara, as last article we present *Quadrotor Helicopter with Open Architecture*, by Charre-Ibarra, Saida, Vidal-Ortega, Erik, Gudiño-Lau, Jorge and Duran-Fonseca, Miguel, with adscription in the Universidad de Colima.

Content

Journal of Technical Education 8[20]1-15: e1820115
Article

Development of new standardized methods for calculating fuel poverty index: a study in the coast of Cabo Corrientes Jalisco

Desarrollo de una nueva metodología estandarizada para el cálculo del índice de pobreza energética: Estudio de caso en la Región Costera de Cabo Corrientes, Jalisco

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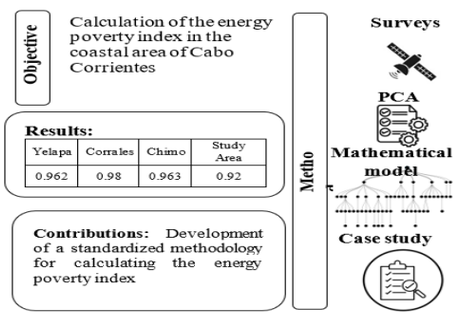
Abstract

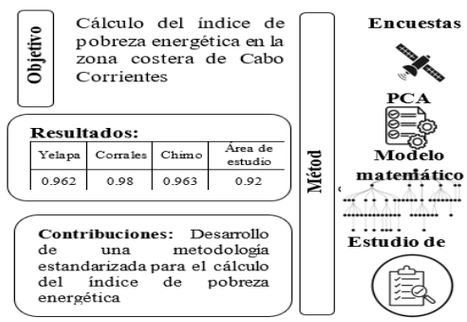
Fuel poverty poses a significant challenge to communities worldwide, particularly in vulnerable regions. Within this context, energy poverty is understood as the inability of households to access basic energy services, representing a barrier to sustainable development and social welfare. This article addresses the need for the development of standardized methodologies for measuring and analyzing energy poverty. In response to the absence of unified approaches for comparative analysis of energy poverty across different geographical contexts, this paper proposes a new methodology, based on data collected from coastal localities in the State of Jalisco. A principal component analysis was conducted, generating a normalized multivariate matrix, and through clustering analysis, similar criteria were grouped into different analytical categories. By applying this method, an adaptation of the Gini Index and Lorenz curves was achieved to precisely calculate an Energy Poverty Index, specifically in the coastal region of Cabo Corrientes, Jalisco.



Energy, Poverty, Indicators

Resumen

La pobreza energética es un importante desafío a nivel mundial, específicamente en regiones vulnerables, se entiende bajo este contexto como la incapacidad para acceder a servicios básicos de energía, representando esto un obstáculo para el desarrollo sostenible y el bienestar social. Este artículo aborda la necesidad del desarrollo de metodologías estandarizadas para la medición y análisis de pobreza energética. En respuesta a una falta de enfoques unificados para la realización comparativa en diversos contextos geográficos, en este artículo se propone una nueva metodología. Se realizó un análisis de componentes principales, generando una matriz multivariada normalizada, y, a través de un análisis de clustering se lograron agrupar criterios similares en diferentes categorías de análisis. Mediante el método aplicado, se logró crear una adaptación del Índice de Gini y las curvas de Lorenz para calcular de manera precisa un Índice de Pobreza Energética, concretamente en la región costera de Cabo Corriente, Jalisco.



Indicadores, Pobreza, Energética

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Introduction

There are several communities around the world where fuel poverty (FP) represents a challenge of vital importance; however, it is impossible to make comparative studies that could lead to the development of strategies which can correct the problem due to the great variety of methods and indicators created to identify them. None of the current methods contain a homogeneous criterion to estimate the indicators and compare them with one another.

Moreover, these indicators are based on specific problems which are present within each region where they were designed and applied. Therefore, this article attempts to explain the development of a standardized mathematical method through which a homogeneous criterion to estimate such indicators with comparable outcomes regardless of the region or social context in which it's applied. Having said this, we have analyzed the coast of Cabo Corrientes in Jalisco.

The concept of fuel poverty isn't a new term. It was first used by Brenda Boardman, an investigator from Oxford University, in her works 'Fuel Poverty: from cold homes to affordable warmth' and 'Fuel Poverty is different' published in 1991. In these publications a differentiation between general poverty and fuel poverty is made analyzing the possible causes and solutions for both. These analyses use as key factors thermal comfort and fuel efficiency.

These factors separate such demands in comfort demand and thermal demand and how much income is allotted for each. In this study, Boardman focused on the social and economy situations in the United Kingdom (UK) at that time which resulted in the term 'fuel poverty' defined as: "the lack of money to provide thermal demand" (Broadman, 1991).

For this term, thermal comfort needs were considered in the UK only. The term can be applied to several regions in Europe where they measure how much of a household's income is allotted for heat. "It is said that a household lacks fuel efficiency when more than 10% of its income is spent for this purpose" (Comision European, 2022)

This way of assessment has been the subject of debate focusing on the advantages and disadvantages of using the indicators for the analysis of all these regions thus creating different methods like in the study by Healy & Clinch (2002) and Healy & Clinch (2004) which concluded that there are clear disadvantages with this lack of standardized methods of assessment to create comparable outcomes. Moreover, regression in these types of evaluations is apparent when one sees logic deviations and confusions when solutions for fuel poverty are sought.

In addition, methods used to create indicators must meet certain requirements as to not obtain independent variables which don't overlap with one another.

In Mexico, Rigoberto Garcia Ochoa and Boris Graizbord developed a multidimensional index for fuel poverty called Multidimensional Energy Poverty Index (MEPI) which was catered to assess the region's characteristics.

Using this index, it was estimated that 36.7% of households in Mexico live in FP according to the 2016 census done by INEGI Mexican acronym for National Institute for Geographic and Statistical Analysis (Garcia Ochoa, 2016).

This indicator takes into account at least one of the basic services and/or economical assets for basic human needs.

To attain this percentage, a method which used only territorial dimensions was used and compared to the outcomes mentioned above yield results with the same value; therefore, it lacks a homogeneous definition and criteria for proper assessment (Garcia Ochoa, 2016).

Once the problem in the previous studies was analyzed (Castaño Rosas Raul, 2020), it was determined that none of the assessment tools have a standardized criterion for evaluating FP.

This shows a clear disadvantage when outcomes can't be compared. This agrees with the report by Healy & Clinch (2002), Healy & Clinch (2004), Thomson Snell (2013).

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Regarding the percentage calculation, there many variables which must play a role in such assessment like: energy needs of different latitudes, atmospheric and socio-cultural conditions. In addition, percentages calculated by the evaluators shouldn't only be based on results from a particular region; a standard method must be in place.

These are some of the reasons this study proposes the creation of an indicator for fuel poverty (IFP) that adequately show the outcome using a homogeneous method which include the global energy factors: distribution of energy, stability, perception of the study subject, to name a few. T

able 1 shows a list of articles which have been broadly analyzed related to fuel poverty calculations throughout the world according to the country, type of indicators, and index used.

It also demonstrates the lack of a standard method to get the percentages in the multidimensional energy poverty index (MEPI) mentioned by Nussbaumer (2012): "We assigned relative weights to the various dimensions and indicators, recognizing the arbitrary nature of such process. However, there are strong reasons to believe that the energy poverty variables considered in the poverty matric are not of equal importance. This notwithstanding, we stress the fact that a weighing structure is value-laden and that the weights used in this analysis, as well as the as the selections of the indicators, are indicative and for the purpose of demonstrating the methodology. That ought to be adapted to te specificities of the analyses." Nussbaumer presents one of the most important and applied mentioned in several articles published so far, even though none of them have a standard method to assign relative weights.

The table shows the articles analyzed, emphasizing the index used, the population and the type of indicator

Box 1

Table 1

Reference of Fuel Poverty Article Analyzed

Reference	Article	Study Location	Indicator	Index
(Abubakari Ahmed, 2020)	Multi-dimensional energy poverty patterns around industrial crop projects in Ghana: Enhancing the energy poverty alleviation potential of rural development strategies	Ghana	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Alexandru Maxim, 2016)	Implications and measurement of energy poverty across the European union	European Union	Energy policy	Exact logistic regression
(Anver C. Sadath, 2017)	Assessing the extent and intensity of energy poverty using Multidimensional Energy Poverty Index: Empirical evidence from households in India.	India	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Castaño Rosas Raul, 2020)	Presentation of an index for evaluating vulnerability to energy poverty according to monetary, energy, and thermal comfort factors	Salford, UK	Household	Index of Vulnerable Homes (IVH)
(Castaño-Rosa Raúl, 2019)	Transferring the index of vulnerable homes: Application at the local-scale in England to assess fuel poverty vulnerability.	UK	Household	Index of Vulnerable Homes (IVH)
(Celedonio B. Mendoza Jr., 2019)	Understanding multidimensional energy poverty in the Philippines.	Philippines	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Diego Seuret-Jimenez, 2020)	Measurement of Energy Access Using Fuzzy Logic.	Mexico	Household	Fuzzy Logic
(Eva Llera-Sastresa, 2017)	Energy vulnerability composite index in social housing, from a household energy poverty perspective.	Spain	Household	Energy Vulnerability Composite Index
(Fabbri, 2015)	Building and fuel poverty, an index to measure fuel poverty: An Italyn case study.	Italy	Household	Building Fuel Poverty index
(Fu Wang, 2023)	Does energy poverty really exist in China? From the perspective of residential electricity consumption.	China	Household	Low Income High Cost (LIHC)
(Jakub Sokołowski, 2020)	A multidimensional index to measure energy poverty: the Polish case	Poland	Household	Low Income High Cost (LIHC)
(João Pedro Gouveia, 2019)	Energy poverty vulnerability index: A multidimensional tool to identify hotspots for local action.	Portugal	Household/ Energy policy	Energy Poverty Vulnerability Index (EPVI)
(Judit Mendoza Aguilar, 2019)	Improving Indicators for Comparing Energy Poverty in the Canary Islands and Spain.	Spain/ Canary Islands	Household	Compound Energy Poverty Indicator (CEPI)
(Ke Wang, 2015)	Energy poverty in China: An index based comprehensive evaluation.	China	Household	Comprehensive Energy Poverty Evaluation Index
(Lefkothea Papada, 2018)	A Stochastic Model for energy poverty analysis.	Greece	Household	Stochastic Energy Poverty Model (PEMP)
(Malla, 2013)	Household energy consumption patterns and its environmental implications: Assessment of energy access and poverty in Nepal.	Nepal	Household	Energy Development Index
(März, 2018)	Assessing the fuel poverty vulnerability of urban neighborhoods using a spatial multi-criteria decision analysis for the German city of Oberhausen.	Germany	Household	Fuel Poverty Index (FPI)
(Mazzone, 2020)	Thermal comfort and cooling strategies in the Brazilian Amazon. An assessment of the concept of fuel poverty in tropical climates	Brazil	Energy policy	Case Study
(Nadiia Pysar, 2018)	Composite fuel poverty index as a means to assess energy security of the country.	Ukraine	Household/ Energy policy	Fuel Poverty Index (FPI)
(Nora Bonatz, 2019)	A comparative study of the interlinkages between energy poverty and low carbon development in China and Germany by developing an energy poverty index.	China/ Alemania	Household	Energy Poverty Index
(Okushima, 2017)	Gauging energy poverty: A multidimensional approach.	Japan	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Okushima, 2019)	Understanding regional energy poverty in Japan: A direct measurement approach.	Japan	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Oscar S. Santillán, 2020)	Analysis of energy poverty in 7 Latin American countries using multidimensional energy poverty index.	7 Latin American countries	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Patrick Nussbaumer F. F., 2013)	Global insights based on the multidimensional energy poverty index (MEPI).	Multiple countries	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Patrick Nussbaumer M. B., 2012)	Measuring energy poverty: Focusing on what matters, Renewable and Sustainable.	Multiple countries	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Pino-Mejías Rafael, 2018)	Artificial neural networks and linear regression prediction models for social housing allocation: Fuel Poverty Potential Risk Index.	Chile	Household	Fuel Poverty Potential Risk Index
(Quishpe Sinailin Pablo, 2019)	Energy poverty in Ecuador.	Ecuador	Household	Multi-dimensional Energy Poverty Index (MEPI)
(Rupali A. Khanna, 2019)	Comprehensive energy poverty index: Measuring energy poverty and identifying micro-level solutions in South and Southeast Asia.	Tailandia, Philippines, Indonesia, Camboya and India	Household	Comprehensive Energy Poverty Index
(T.R. Ayodele, 2018)	Electrical energy poverty among micro-enterprises: Indices estimation approach for the city of Ibadan, Nigeria.	Nigeria	Companies	Composite Electrical energy Poverty Index
(Tabitha Atieno Olang, 2018)	Lighting and cooking fuel choices of households in Kisumu City, Kenya: A multidimensional energy poverty perspective.	Kenya	Household/ Energy policy	Multi-dimensional Energy Poverty Index (MEPI)
(Tait, 2017)	Towards a multidimensional framework for measuring household energy access: Application to South Africa.	South Africa	Household	Energy Access Index

Methodology

A study was conducted with the purpose of creating an adequate standardized method to calculate the fuel poverty index in the coastal region of Cabo Corrientes. It was found that the locations where the analysis was done through a survey the problem is clear.

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Survey

Data collected by ENCEVI (National Survey for Energy Consumption by Private Homes, 2018) yielded the information used for the study. The survey is made up of specific questions which are designed to obtain the amount of energy used per household. Access and quality of services were also assessed as well as the resources used to produce this energy. Moreover, access to potable water and its distribution (drainage and piping), the use of essential electric appliances necessary to have an optimum quality of life, house size and characteristics were also studied.

Box 2

Table 2

Survey Questions Description

Questions Number	Topic for Each Question	Number of Questions
1	House Characteristics	5
2	Water Supply	4
3	Electric Supply	6
4	Appliances	39
5	Heating and Air Conditioning	3
6	Service Reliability	7
7	Other	4

Table 2. Shows the points asked to the people surveyed

Field work

A map of the communities in the study was developed along with distances within Cabo Corrientes to pinpoint the proper anchor point for the study. From this point, radii of 10 to 40 kilometers were drawn to the different communities and their population was censused (National Income and Expenses in the Home Survey 2018, 2019).

Box 3

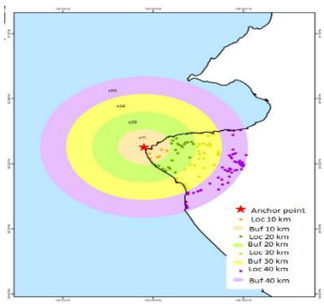

Figure 1

Map of radios Study Area

Map the coast of Jalisco with radios of locations and distances from Cabo Corrientes

11 communities were selected from this map (table 3) to be analyzed. These places were selected for their population statistics and access.

Based on this criterion the following locations were chosen: Yelapa located within a ~30 km radius, El Chimo located within a ~20 km radius, and Corrales located within a ~10 km radius.

Box 4

Table 3

Population According to Census INEGI 2020

Locations in the Vicinity of Anchor Point	Population by 2020
La palmita	2
Pizota	63
Manzanillas	12
Tecomata	1
El Chimo	221
Tabito	2
Los Corrales	219
El Faro	2
Yelapa	715
Las Playitas	23
Revolución Mexicana	8

Table 3. Populations within a 10 km radius indicating the current population until 2020

Once the locations were established, the calculation of the sample size was estimated for the study. The amount of samples was determined through surveys: 25 in Yelapa, 28 in El Chimo, and 22 in Corrales. The outcomes are shown in table 4.

Box 5

Table 4

Number of Samples, Inhabitants, Population (INEGI 2020), and Size of Surveyed Samples

Sample Size				
Location	Population (INEGI)	Estimated Number of Inhabitants	Percentage of Trust Perception	% Error
El Chimo	221	91	95	5
Corrales	219	91	95	5
Yelapa	715	88	95	5

Table 4. Percentage of trust perception and error.

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The survey was conducted afterwards trying to interview as many people as possible which in turn yielded the fuel energy index using this new method mentioned in this report in each of the communities in the map. Furthermore, additional information about specific energy needs was collected.

Due to the many methods used to calculate the fuel poverty, as mentioned in the introduction, in which specific location's as well as global characteristics indicators are used, the article by Indre Siksnelyte-Butkiene published in 2021 was analyzed. In this article, 71 indicators are used to calculate the FP using a systematic assessment and evaluation.

However, financial support is indispensable this all methods of investigation. In addition, arbitrary data in indicators make it difficult to get a precise outcome as described by Raul Castaño Rosas in 2020.

FP indexes were determined using Garcia Ochoa (2016) and Patrick Nussbaumer M.B. (2012) methodologies and presuppositions. However, as mentioned before, these don't offer clear and precise results in the indicator weights reason why the outcomes represent a problem when the components become irrelevant in the region studied.

Due to this problem, a multivariable statistic of principal components method was used which was designed at the end of the XIX century by Pearson.

It helps to study the relationship that exists amongst the great number of correlated variables which measure common information without repeating any. This is known as principal components.

Principal Components Analysis

This method is mainly used when there is big number of variables and a great amount of information which in turn makes it necessary to take many correlation coefficients into account.

Coefficients that in many cases yield the same results from different perspectives. Therefore, a reduction of the number of variables which are related to one another is necessary.

To accomplish a reduction of such variables which aren't related with each other, that is, they don't contain repeated information or that they don't measure the same information from different perspectives, the new variables conform a set of lineal combinations from the original variables that are made up according to the order of importance within the sample.

In the analysis of the principal components, $m < p$ variables in which the lineal combinations p are from the original variables. These must be correlated which will conserve most of the information. This translates to data variability which means that when there is more variability there will be more information.

Calculating the Principal Components Analysis (PCA)

First, a series of variables need to be considered $(x_1, x_2, \dots, x_p)$, these variables represent any group objects or characteristics from a group of individuals, such is our case. Using these variables a new set of variables $(x_1, x_2, \dots, x_p)$, both variables must be uncorrelated with one another which will ensure that the variance will decrease progressively.

Each of the variables, y_j, is a linear combination of the original variables $(x_1, x_2, \dots, x_p)$, in which $j = 1, 2, \dots, p$.

That is:

$$y_j = a_{j1}x_1 + a_{j2}x_2 + \cdots + a_{jp}x_p = \boldsymbol{a_j'X} \quad (1)$$

which $\boldsymbol{a_j'} = a_{j1} + a_{j2} + \cdots + a_{jp}$ is a vector of constants, and

$$X = \begin{bmatrix} x_1 \\ \vdots \\ x_p \end{bmatrix} \quad (2)$$

To maintain the orthogonality in the change of the variable, it said that vector module $\boldsymbol{a_j'} = (a_{j1} + a_{j2} + \cdots + a_{jp})$ is calculated as follows:

$$\boldsymbol{a_j'a_j} = \sum_{k=1}^{p} a_{kj}^2 = 1 \quad (3)$$

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To obtain components that uncorrelated with one another, coefficient are calculated $\boldsymbol{a}_j' = a_{j1} + a_{j2} + \cdots + a_{jp}$ making sure that each one of the $y_1, y_2, \ldots . y_n$ have the most variance given that $\boldsymbol{a}_j'\boldsymbol{a}_j = 1$, the same process is done for the following aleatory variables, noting that calculated variance of each component is lower every time.

To interpret the relative weights correctly, the correlation must be normalized.

In this study, 68 questions were used in 3 different communities (table 1) which were considered the based variables (Eq. 1). Afterward, the uncorrelated variables which contain the linear combination of the original variables represented by a vector made with constants by Eq. 2 and which maintain and orthogonality (Eq. 3) with each other.

Each resulting variant was less than the one before, this complies with the condition of being bounded between 0 and 1. Using this procedure a normalized multivariate correlation matrix was calculated.

Clustering Method

The clustering analysis is an exploring methodology whose main use us to classify or categorize a group of data into homogenous sets. Given that a group of N elements characterized by information of n variables $X_j, (j = 1,2,\ldots,n)$, we challenged ourselves to classify them so that the pertaining data in a cluster was as similar as possible to the other according to the established criteria. This enables us to have different groups as dissimilar as possible, Taylor & Francis (1990).

K-Means Method

This methos is one the most widely used in practice because it categorizes different data into several predetermined groups. In this paper 3 groups were determined in which the main causes for fuel poverty in the region.

To analyze the groupings and addition minimizing the quadratic distances between each data and the centroid per group is known as a cluster.

Group Analysis

Once the method is applied, the reduction in the variable dimensionality was determined and the 10 categories were formed which are:

Hygiene
- Water access
- Water collection
- Sewage
- Water service perception
- Water distribution

Electric Power access
- Grid stability
- Constant distribution
- Distribution cost

Quality of Life
- Thermal comfort
- Food Refrigeration

Once the groups by the K-means method, the variables and the respective statistics were categorized in each of the criterion for each of the coastal microregions. The categories were sanitation, access to electric power, and quality of life adapted from the Yuan & Yang method (2019).

Using these 3 categories, an equation was proposed in this way:

$$Equation = aA + eE + cC \quad (4)$$

Composed by:

$$A = A_1 + A_2 + A_3 + A_4 + A_5 \quad (5)$$
$$E = E_1 + E_2 + E_3 \quad (6)$$
$$C = C_1 + C_2 \quad (7)$$

Where:

A = Sanitation
- A_1 =Potable Water Access
- A_2 =Water Storage
- A_3 =Drainage
- A_4 =Water Distribution Perception
- A_5 =Water Distribution

E = Electric Power Access
- E_1 = Distribution Stability
- E_2 = Distribution Constancy
- E_3 = Distribution Cost

C = Quality of Life
- C_1 = Thermal Comfort
- C_2 = Food Refrigeration

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Box 6

Table 5

Multivariable Matrix

Dimension	Indicator %	Indicator %
Sanitation	Access to Potable Water	Water Storage
	Water Distribution Perception	Drainage
	Water Distribution	
Electric Power Access	Distribution Stability	Distribution Constancy
	Distribution Cost	
Quality of Life	Thermal Comfort	Food Refrigeration

Table 5. Order of Indicators for the Multivariable Matrix.

Least Square Method was used to get the coefficients for equation 4.

Gini Coefficient and Lorenz Curve

Gini's Coefficient is used in economics to calculate wealth distribution in the different economic factors and Lorenz Curve is used to see area proportions (see graph).

Box 7

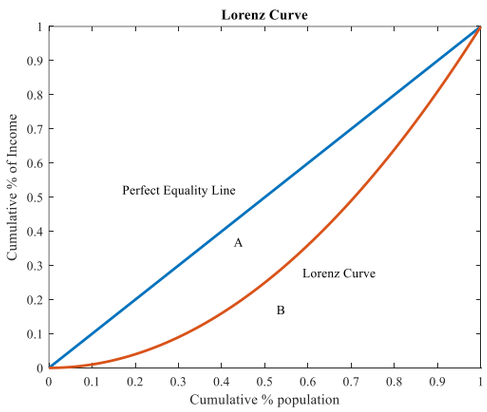


Figure 2

Lorenz curve

.

In figure 2, the square's mediatrix corresponds to the equality line. Area A in the graph is between this straight line and Lorenz Curve which describes the income distribution pointing out the closest the lines are to one another the better the wealth distribution is.

The Gini Coefficient is calculated as quotient of the area $A/(A + B)$ shown in figure 2; its value is between 0 and 1; 0 represents a perfect and equal wealth distribution. The result of this equation is then multiplied by 100 to get the Gini index.

This coefficient can be used to measure any unequal distribution. (Rodríguez, 2013)

Once the results were estimated, an adaptation of the Gini index was used. Then, a criteria to determine if a community has fuel poverty was designed.

0 - 0.25 Low EPOV
0.25 – 0.50 Moderate EPOV
0.51 - 0.75 High EPOV
0.76 – 1 Extreme EPOV

Results

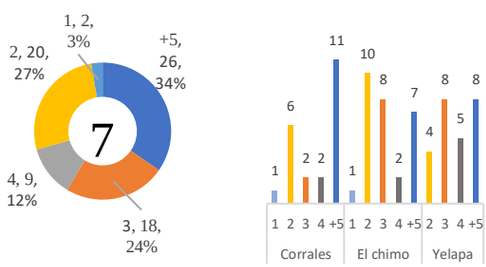
The 3 studied locations were analyzed independently as well as a group considering house characteristics, thermal comfort, and energy efficiency.

The materials used in the construction of the houses played an important role focusing on walls and roofs and how these satisfy the needs to the house inhabitants.

These parameters determined if there was a lack housing infrastructure such as overcrowding and long-lasting building materials (over 30 years). One must not forget the square-footage per room within each house to state that overcrowding exists.

Box 8

How many people live in your house?



Graph 1

Number of inhabitants per house in the 3 locations

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75 houses were surveyed: 34% had more than 5 inhabitants, 27% had 2, 24% had 3, 12% had 4 and 3% had only 1 inhabitant.

The 3 types of floor materials in the 75 houses that were surveyed 96% were made of cement, 3% were made from bricks and 1% had no floor.

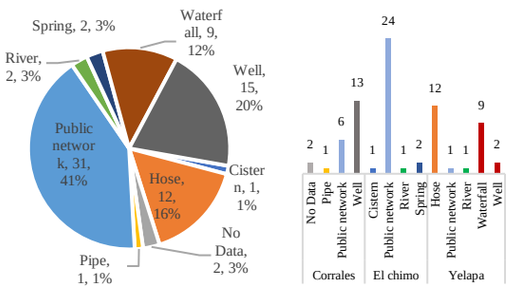
Distribution, cost of distribution, and stability of basic services were studied in the zone. The 3 locations have electric power supplied by Federal Electric Commission (FEC). Water is supplied through various ways (see graph 2). Houses that have internet services was mostly by a satellite provider.

Most of the surveyed houses reported having septic tank for waste disposal. All these factors must be considered to assess the quality of life in the studied locations.

It's worth mentioning that most of the people surveyed said the water grid is connected to a waterfall which in turn brings water to their homes.

Box 9

How does water get to your house?



Graph 2

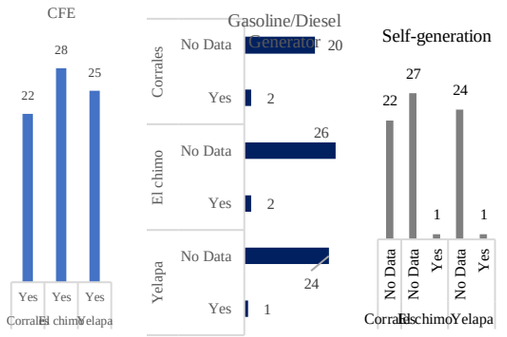
Water distribution methods by location

Graph 2. 41% said that their water was distributed by the public grid, 15% is obtained from a well, 12% comes from a waterfall, 3% from a natural spring or river, 1% is delivered by a water truck.

Water storage is kept in above level water cisterns place on the roofs of the house, in water deposits underground and least of all in buckets. 68 of the 75 surveys report having septic tanks for waste drainage and 5 reported they were connected to the public sewage system.

Box 10

How does light get to your house?



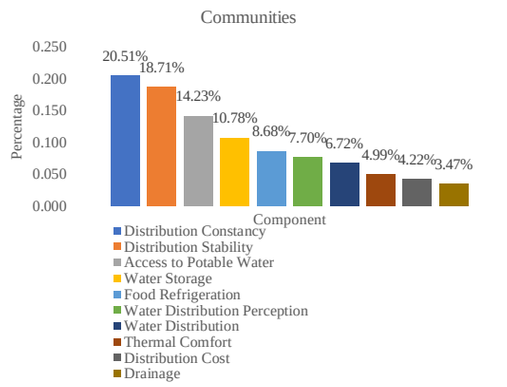
Graph 3

Type of electricity supply by locality

Graph 3. Most of the houses surveyed get electric power from the CFE. Some of the houses have an alternative source of power

The problem of the power supplied is perceived as grave by 57% of the houses surveyed who reported daily failures in 53 households, 13 households considered the problem bad, 14 report as not so bad of problem reporting failures every week, and 4 considered the problem as a small problem with only once a fortnight or every month.

Box 11



Graph 4

Percentage Variance in the 3 communities using PCA method

Graph 4. Percentage Variance in the calculation in the 3 communities using PCA method.

36 houses surveyed report failures every month, 16 report weekly failures, 12 report daily failures, 5 report failures every fortnight, 2 report never having a problem, 15 report as not grave, and 14 say as not as bad, and 11 report a very grave problem.

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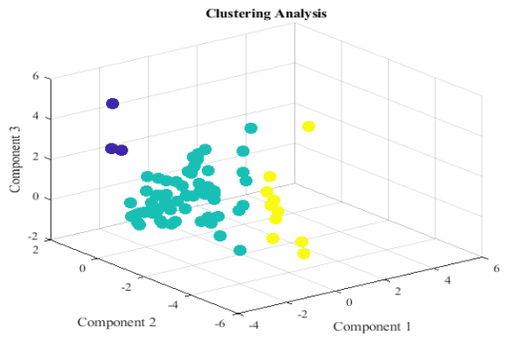
To get the percentage of variance of each indicator an exploratory analysis using the PCA method was used which showed the data behavior and the reduction in dimensionality of such data. This yielded the dimensional indicators used in complete study. Afterwards, the clustering method was used to determine the groups indicators resulting in 3 categories as shown the graph 5 in which the purple color corresponds to quality of life, green to sanitation and yellow to access to electric power. Using these results the 3 principal causes fuel poverty in the region.

Box 12



Graph 5

Number of clusters for the 3 communities

Graph 5: Number of clusters for the 3 communities within the study: purple – quality of life, green – sanitation, yellow – electric power

These tables show the sizing of the indicators (percentages) in the three groups in each community in the region for the 3 categories.

Box 13

Table 6

Estimated percentages in the 3 communities within the studied area

Dimension	Indicator %	Indicator %
Sanitation (0.43)	Access to Potable Water (14.23)	Water Storage (10.78)
	Water Distribution Perception (7.70)	Drainage (3.47)
	Water Distribution (6.72)	
Electric Power Access (0.44)	Distribution Stability (18.71)	Distribution Constancy (20.51)
	Distribution Cost (4.22)	
Quality of Life (0.13)	Thermal Comfort (4.99)	Food Refrigeration (8.68)

Table 6. Order of the indicators of the multivariable matrix with the corresponding percentages for the study area.

In the same way, the variance percentages were calculated for Corrales using the corresponding preestablished indicators.

Box 14

Table 7

Estimated percentages in Corrales

Dimension	Indicator %	Indicator %
Sanitation (0.36)	Access to Potable Water (6.63)	Water Storage (14.63)
	Water Distribution Perception (2.42)	Drainage (3.53)
	Water Distribution (9.22)	
Electric Power Access (0.2)	Distribution Stability (1.27)	Distribution Constancy (13.61)
	Distribution Cost (4.67)	
Quality of Life (0.44)	Thermal Comfort (21.8)	Food Refrigeration (22.22)

Table 7. Estimated percentages using the multivariable correlated indicators matrix in Corrales.

In the same way, the variance percentages were calculated for Yelapa using the corresponding preestablished indicators.

Box 15

Table 8

Estimated percentages in Yelapa

Dimension	Indicator %	Indicator %
Sanitation (0.45)	Access to Potable Water (22.06)	Water Storage (5.71)
	Water Distribution Perception (12.51)	Drainage (2.72)
	Water Distribution (2.29)	
Electric Power Access (0.37)	Distribution Stability (17.85)	Distribution Constancy (14.29)
	Distribution Cost (4.59)	
Quality of Life (0.18)	Thermal Comfort (7.35)	Food Refrigeration (10.64)

Table 8. Estimated percentages using the multivariable correlated indicators matrix in Yelapa

In the same way, the variance percentages were calculated for El Chimo using the corresponding preestablished indicators.

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Box 16

Table 9

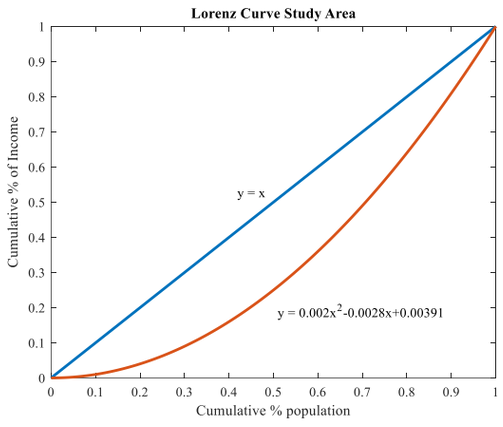
Estimated percentages in El Chimo

Dimension	Indicator %	Indicator %
Sanitation (0.25)	Access to Potable Water (4.02)	Water Storage (13.43)
	Water Distribution Perception (5)	Drainage (1.6)
	Water Distribution (0.89)	
Electric Power Access (0.41)	Distribution Stability (14.05)	Distribution Constancy (7.89)
	Distribution Cost (19.24)	
Quality of Life (0.34)	Thermal Comfort (6.49)	Food Refrigeration (27.39)

Table 9. Estimated percentages using the multivariable correlated indicators matrix in El Chimo.

An adaption of the Lorenz Curve was used in which a quadratic regression was applied using the results obtain from the PCA method to calculate the corresponding equation. Then, a Lorenz Curve was graphed along the perfect equality line for each community.

Box 17



Graph 6

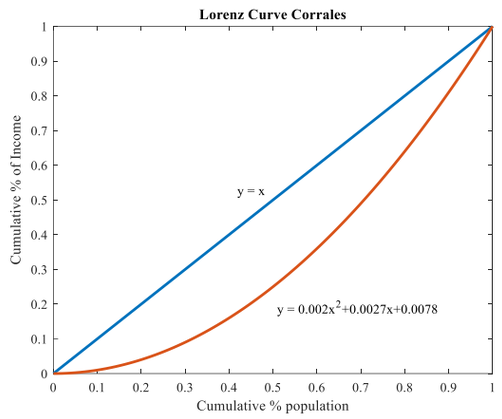
Lorenz Curve Adaptation for the 3 communities in the Study

Graph 5. Adaptation of the Lorenz Curve for the 3 communities of the Study, where the equations for the Lorenz curve and for the line of perfect equality are shown.

Using Gini's coefficient as a base, calculated by quotient of the areas A/(A + B) (see figure 2), to get the area between both equations, which results in the fuel poverty index, a definite integral was used (see equation 4). This determined the fuel poverty index (FPI) and the value which is between 0 and 1.

$$\text{IPE} = 2 * \int_0^1 [x - (0.002x^2 - 0.0028x + 0.00391)]dx \quad (8)$$

Box 18



Graph 7

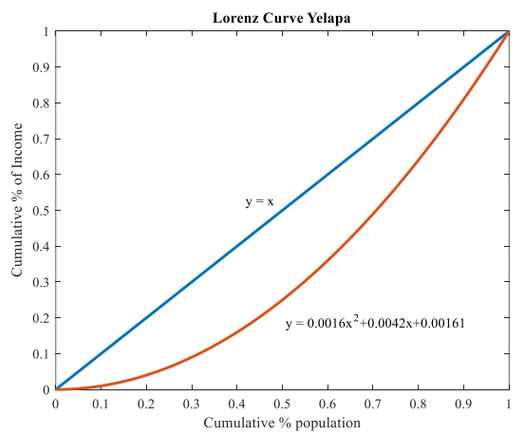
Lorenz Curve Adaptation for Corrales

Graph 6. Adaptation of the Lorenz Curve Corrales of the Study, where the equations for the Lorenz curve and for the line of perfect equality are shown.

In the same way, the corresponding definite integral for Corrales was made.

$$\text{IPE} = 2 * \int_0^1 [x - (0.002x^2 + 0.0027x + 0.0078)]dx \quad (9)$$

Box 19



Graph 8

Lorenz Curve Adaptation for Yelapa

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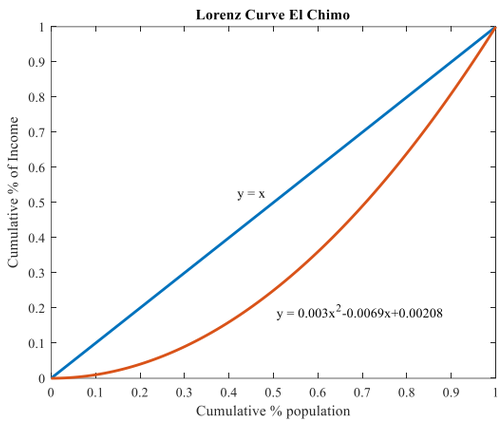
Graph 7. Adaptation of the Lorenz Curve for Yelapa of the Study, where the equations for the Lorenz curve and for the line of perfect equality are shown.

In the same way, the corresponding definite integral for Yelapa was made.

$$\text{IPE} = 2 * \int_0^1 [x - (0.0016x^2 + 0.0042x + 0.0161)]dx \quad (10)$$

Box 20



Graph 9

Lorenz Curve Adaptation for El Chimo

Graph 8. Adaptation of the Lorenz Curve for El Chimo of the Study, where the equations for the Lorenz curve and for the line of perfect equality are shown.

In the same way, the corresponding definite integral for El Chimo was made.

$$\text{IPE} = 2 * \int_0^1 [x - (0.003x^2 - 0.0069x + 0.0208)]dx \quad (11)$$

Using the latter method, the FPI for each to the surveyed communities was calculated individually for the area of this study.

Box 21

Table 10

Fuel Energy Index of the surveyed communities

Yelapa	Corrales	Chimo	Study Area
0.962	0.98	0.963	0.92

Table 10. Energy poverty index is shown in which the surveyed communities and the study area are located.

Conclusions

Considering the scale of results on which the reference parameter is between 0.79 – 1, tell us that the 3 communities are in extreme FPI. Showing that Corrales is the location that has the most FPI.

Also the most difficult to reach; whereas Yelapa is the one most accessible out of the 3 communities studied. However, one must consider that only basic needs for quality of life, power distribution and power resources stability were considered for the development of this analysis resulting a presentative estimate for these locations which show a more precise and standardized representation of the FPI.

However, these FPI results aren't comparable to any studies done before because the percentages obtained are results of implied suppositions which identify whether a home has fuel poverty were attained in a standardized statistical manner. Problem which is explained in detail in this study.

Even though more recent studies have used techniques such as Machine Learning (ML), Artificial Neural Networks (ANN), nested weighting and GRA-SRA, etc. (Gawusu, S. & Ahmed, A (2024), García, C. L. E. & Toro-García, G. L. (2024), Raza, A., Khokhar, M., Ejaz, S., Ejaz, F., Kosztyi, D Júlia, F Z. & Hossain, M B. (2024), Al Kez, D., Foley, A., Abdul, Z. K. & Del Rio, D. F. (2024)) to calculate the indicators, the implicit assumptions lack of unified approaches for the comparative realization of energy poverty in various contexts.

Therefore, it is concluded that the method shown provides a new standardized methodology tool to calculate the FPI that will enable the comparable analysis in different and distinct regions which will yield in global strategies to solve problems like this worldwide.

This project showed a method to calculate the Fuel Poverty Index. This methodology represents a series of advantages never found in previous methods used before.

These advantages are:

1. It is possible to apply it to any location

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2. The calculation of the weightings for the indicators depends only on the availability of the basic services for quality of life in humans as well as on the distribution and stability of such services with the respective location.
3. A defined and homogenous method doesn't depend on territorial dimensions, access or latitude,
4. Only conditions present throughout the world are considered such as electric power factors, power distribution, stability and the perception of these services, and
5. It allows the analysis which can be compared with other regions.

All these are the advantages found compared to previous studies. This gives a new standardized methodology to get the Fuel Poverty Index.

Declarations

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contribution

Cerda-Carrillo, Nely: Contributed to: Conceptualization, Survey data collection, Methodology, Validation, Formal analysis, Investigation, Writing – original draft.

Sandoval-Hernández Erika: Contributed to: Survey data collection, Supervision, review & editing.

Vega-Gómez, Carlos Jesahel: Contributed to: Conceptualization, Resources, review & editing. Rojas Ramírez José Juan Pablo, Contributed to: Supervision formal analysis, review & editing.

Availability of data and materials

The products related to the INEGI population and housing census and distributed at (https://www.inegi.org.mx/programas/ccpv/2020/), as well as the National Survey of Household Income and Expenses and Survey National on Energy Consumption in Private Homes: ENCEVI

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Abbreviatures

ANN: Artificial Neural Networks
CEPI: Compound Energy Poverty Indicator
ENCEVI: National Survey for Energy Consumption by Private Homes
EPOV: Energy Poverty Index
EPVI: Energy Poverty Vulnerability Index
FEC: Federal Electric Commission
FP: Fuel Poverty
FPI: Fuel Poverty Index
GRA: Grey Relational Analysis
IFP: Indicator for Fuel Poverty
INEGI: Instituto Nacional de Estadística y Geografía
IVH: Index of Vulnerable Homes
LIHC: Low Income High Cost
MEPI: Multidimensional Energy Poverty Index
ML: Machine Learning
PCA: Principal Components Analysis

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PEMP: Stochastic Energy Poverty Model
SRA: Simple Ranking Approach
UK: United Kingdom

References

Antecedents

Boardman, B. (1991). Fuel poverty: from cold homes to affordable warmth. Belhaven Press, London.

Castaño Rosas Raul, S. G. (2020). Indicadores de pobreza energética: una revisión sistemática de la literatura y un análisis integral de la integridad. Revista hábitat sustentable, 9-21.

Comision Europea. (2022, 0216). Retrieved from

García Ochoa, R. G. (2016). Caracterización espacial de la pobreza energética en México. Un análisis a escala subnacional. Economía, sociedad y territorio, 289-337.

Harriet Thomson, C. S. (2013). Quantifying the prevalence of fuel poverty across the European Union. Energy Policy, 563-572.

Healy, J. D., & Clinch, J. P. (2002). Fuel poverty, thermal comfort and occupancy: results of a national household-survey in Ireland. Applied Energy, 73(3-4), 329–343.

Healy, J. D., & Clinch, J. P. (2004). Quantifying the severity of fuel poverty, its relationship with poor housing and reasons for non-investment in energy-saving measures in Ireland. Energy Policy, 32(2), 207–220.

Patrick Nussbaumer, M. B. (2012). Measuring energy poverty: Focusing on what matters., Renewable and Sustainable. Renewable and Sustainable Energy Reviews, 231-243.

García Ochoa, R. G. (2016). Caracterización espacial de la pobreza energética en México. Un análisis a escala subnacional. Economía, sociedad y territorio, 289-337.

Basics

Castaño Rosas Raul, S. G. (2020). Indicadores de pobreza energética: una revisión sistemática de la literatura y un análisis integral de la integridad. Revista hábitat sustentable, 9-21.

Censo de Población y Vivienda 2020. (2021, 01 25). Retrieved from

Cuadras, C. M. (2014). Nuevos Métodos de Análisi Multivariante. Barcelona, Spain: CMC Editions.

Encuesta Nacional de Ingresos y Gastos de los Hogares 2018. (2019, 07 13). Retrieved from

Encuesta Nacional sobre Consumo de Energéticos en Viviendas Particulares. Encuesta Nacional sobre Consumo de Energéticos en Viviendas Particulares : ENCEVI. (2018).

García Ochoa, R. G. (2016). Economía, sociedad y territorio, 289-337.

Indre Siksnelyte-Butkiene, D. S. (2021). Energy poverty indicators: A systematic literature review and comprehensive analysis of integrity. Sustainable Cities and Society.

Instituto de Información Estadística y Geográfica de Jalisco. (2020). Retrieved from Zona Costera. IIEG.

Patrick Nussbaumer, M. B. (2012). Measuring energy poverty: Focusing on what matters., Renewable and Sustainable. Renewable and Sustainable Energy Reviews, 231-243.

Rodríguez, C. E. (2013). Diccionarios, Econimía y Administración. Mendoza: Facultad de Humanidades y Ciencias Económicas.

Sarle, W. S. (1990). Algorithms for Clustering Data. Technometrics, 32(2), 227–229.

Yuan, C., & Yang, H. (2019). Research on K-value selection method of K-means clustering algorithm. J, 2(2), 226-235.

Supports

Castaño-Rosa, Raúl S. G. (2019). Transferring the index of vulnerable homes: Application at the local-scale in England to assess fuel poverty vulnerability. Energy and Buildings, 109-458.

Castaño Rosas Raul, S. G. (2020). Indicadores de pobreza energética: una revisión sistemática de la literatura y un análisis integral de la integridad. Revista hábitat sustentable, 9-21.

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https://doi.org/10.35429/JTE.2024.8.20.1.15

Diego Seuret-Jimenez, T. R.-B. (2020). Measurement of Energy Access Using Fuzzy Logic. Energies.

Oscar S. Santillán, K. G. (2020). Analysis of energy poverty in 7 Latin American countries using multidimensional energy poverty index. Energies.

Patrick Nussbaumer, F. F. (2013). Global insights based on the multidimensional energy poverty index (MEPI). Sustentability, 2060-2076.

Patrick Nussbaumer, M. B. (2012). Measuring energy poverty: Focusing on what matters., Renewable and Sustainable. Renewable and Sustainable Energy Reviews, 231-243.

Pino-Mejías, Rafael A. P.-F.-B.-A. (2018). Artificial neural networks and linear regression prediction models for social housing allocation: Fuel Poverty Potential Risk Index. Energy, 627-641.

Quishpe Sinailin Pablo, T. d. (2019). Energy poverty in Ecuador. Sustentability, 1-19.

Differences

Abubakari Ahmed, A. G. (2020). Multi-dimensional energy poverty patterns around industrial crop projects in Ghana: Enhancing the energy poverty alleviation potential of rural development strategies. Energys, 111-123.

Alexandru Maxim, C. M.-M. (2016). Implications and measurement of energy poverty across the European union. Sustentability.

Anver C. Sadath, R. H. (2017). Assessing the extent and intensity of energy poverty using Multidimensional Energy Poverty Index: Empirical evidence from households in India. Energy Policy, 540-550.

Celedonio B. Mendoza Jr., D. D. (2019). Understanding multidimensional energy poverty in the Philippines. Energy Policy, 110-886.

Eva Llera-Sastresa, S. S.-T.-B.-U. (2017). Energy vulnerability composite index in social housing, from a household energy poverty perspective. Sustentability.

Fabbri, K. (2015). Building and fuel poverty, an index to measure fuel poverty: An Italian case study. Energy, 244-258.

Fu Wang, H. G. (2023). Does energy poverty really exist in China? From the perspective of residential electricity consumption. Energy Policy, 45-78.

Jakub Sokołowski, P. L. (2020). A multidimensional index to measure energy poverty: The Polish case. Energy Sources, 92-112.

João Pedro Gouveia, P. P. (2018). Energy poverty vulnerability index: A multidimensional tool to identify hotspots for local action. Energy Reports, 187-201.

Judit Mendoza Aguilar, F. J.-R.-D. (2019). Improving Indicators for Comparing Energy Poverty in the Canary Islands and Spain. Energies.

Ke Wang, Y.-X. W.-M. (2015). Energy poverty in China: An index based comprehensive evaluation. Renewable and Sustainable Energy Reviews, 308-323.

Lefkothea Papada, D. K. (2018). A Stochastic Model for energy poverty analysis. Energy Policy, 153-164.

Malla, S. (2013). Household energy consumption patterns and its environmental implications: Assessment of energy access and poverty in Nepal. Energy Policy, 990–1002.

März, S. (2018). Assessing the fuel poverty vulnerability of urban neighbourhoods using a spatial multi-criteria decision analysis for the German city of Oberhausen. Renewable and Sustainable Energy Reviews, 1701-1711.

Mazzone, A. (2020). Thermal comfort and cooling strategies in the Brazilian Amazon. An assessment of the concept of fuel poverty in tropical climates. Energy Policy, 111-256.

Nadiia Pysar, V. D. (2018). Composite fuel poverty index as a means to assess energy security of the country. Economic Annals-XXI, 50-56.

ISSN: 2523-2460.
RENIECYT-CONAHCYT: 1702902

Cerda-Carrillo, Nely, Vega-Gómez, Carlos Jesahel, Sandoval-Hernández Erika and Rojas-Ramírez, José Juan Pablo. [2024]. Development of new standardized methods for calculating fuel poverty index: a study in the coast of Cabo Corrientes Jalisco. Journal of Technical Education. 8[20]1-15: e1820115.
https://doi.org/10.35429/JTE.2024.8.20.1.15

Nora Bonatz, G. R. (2019). A comparative study of the interlinkages between energy poverty and low carbon development in China and Germany by developing an energy poverty index. Energy and Buildings, 817-831.

Okushima, S. (2017). Gauging energy poverty: A multidimensional approach. Energy, 1159-1169.

Okushima, S. (2019). Understanding regional energy poverty in Japan: A direct measurement approach. Energy and Buildings, 174–184.

Rupali A. Khanna, Y. L. (2019). Comprehensive energy poverty index: Measuring energy poverty and identifying micro-level solutions in South and Southeast Asia. Energy Policy, 379-391.

T.R. Ayodele, A. O. (2018). Electrical energy poverty among micro-enterprises: Indices estimation approach for the city of Ibadan, Nigeria. Sustainable Cities and Society, 344-357.

Tabitha Atieno Olang, M. E. (2018). Lighting and cooking fuel choices of households in Kisumu City, Kenya: A multidimensional energy poverty perspective. Energy for Sustainable Development, 1-13.

Tait, L. (2017). Towards a multidimensional framework for measuring household energy access: Application to South Africa. Energy for Sustainable Development, 1-9.

Discussions

Al Kez, D., Foley, A., Abdul, Z. K., & Del Rio, D. F. (2024). Energy poverty prediction in the United Kingdom: A machine learning approach. Energy Policy, 184, 113909.

García, C. L. E., & Toro-García, G. L. (2024). Multidimensional Energy Poverty in Colombia: A Department-level Review from 2018 to 2022. Heliyon.

Gawusu, S., & Ahmed, A. (2024). Analyzing variability in urban energy poverty: A stochastic modeling and Monte Carlo simulation approach. Energy, 304, 132194.

Raza, A., Khokhar, M., Ejaz, S., Ejaz, F., Kosztyi, D., Júlia, F. Z., & Hossain, M. B. (2024). Sustainable development goals and energy poverty reduction: empirical evidence from N11 countries. International Journal of Energy Economics and Policy, 14(2), 701-710.

ISSN: 2523-2460.
RENIECYT-CONAHCYT: 1702902

Cerda-Carrillo, Nely, Vega-Gómez, Carlos Jesahel, Sandoval-Hernández Erika and Rojas-Ramírez, José Juan Pablo. [2024]. Development of new standardized methods for calculating fuel poverty index: a study in the coast of Cabo Corrientes Jalisco. Journal of Technical Education. 8[20]1-15: e1820115.
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Article

Facing the gap: Digital villages for life transformation small and medium enterprises in Morelos

Enfrentando la brecha: Aldeas digitales para la transformación de pequeñas y medianas empresas en Morelos

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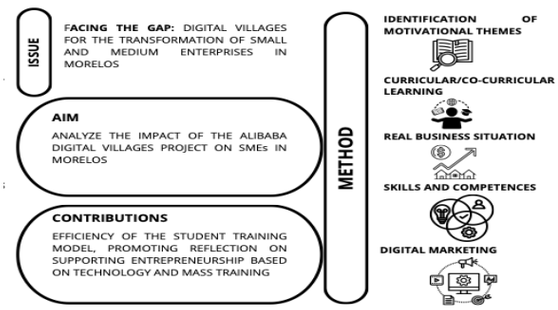
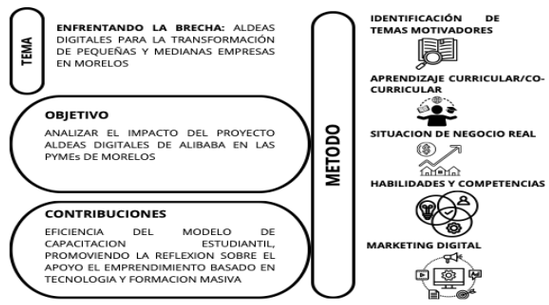
Abstract

Digital Villages project of Alibaba´s Group, carried out in the state of Morelos, due to its transformative effects on Small and Medium Enterprises, was an extraordinary strategy to empower participants through collaboration initiatives between teachers, students, and entrepreneurs, using digital resources to improve the prospects of visibility and commercial development of each project, contributing to the reduction of poverty gaps and job creation. The general methodology adopted by each team, was Project-Based Learning (PBL), which allowed participants to identify motivating topics and learn curricular or co-curricular content, testing their skills and competencies. The challenge of each project was to find out critical situations, considering the reality or environment of each small business, arousing their interest and reinforce concepts and procedures required to learn within marketing and digital resources. The analysis of the small and medium-sized companies that took part of the project led to identify the theoretical and practical characteristics of the Digital Villages project in the state of Morelos and revealed the importance of the Alibaba Business School methodology at the various levels of training. The added value was being able to appreciate the efficiency of the Student Training Model through Agile Methodologies; and promote reflection on the importance and efficiency of supporting small and medium-sized businesses in entrepreneurship, under a model like that of China, based on technology training and mass training.

Resumen

El proyecto Aldeas Digitales del Grupo Alibaba, llevado a cabo en el estado de Morelos, por sus efectos transformadores en las PyMEs, fue una estrategia extraordinaria para empoderar a los participantes a través de iniciativas de colaboración entre profesores, estudiantes y emprendedores, utilizando recursos digitales para mejorar las perspectivas de visibilidad y desarrollo comercial de cada proyecto, contribuyendo a la reducción de las brechas de pobreza y la creación de empleos. La metodología general adoptada por cada equipo, fue el Aprendizaje Basado en Proyectos (ABP), que permitió a los participantes identificar temas motivadores y aprender contenidos curriculares o cocurriculares, poniendo a prueba sus habilidades y competencias. El reto de cada proyecto fue descubrir situaciones críticas, considerando la realidad o entorno de cada pequeña empresa, despertar su interés y reforzar conceptos y procedimientos requeridos para aprender dentro del marketing y los recursos digitales. El análisis de las PyMEs que participaron en el proyecto permitió identificar las características teóricas y prácticas del proyecto Aldeas Digitales en el estado de Morelos y reveló la importancia de la metodología de Alibaba Business School en los distintos niveles de formación. El valor agregado fue poder valorar la eficiencia del Modelo de Formación de Estudiantes a través de Metodologías Ágiles; y promover la reflexión sobre la importancia y eficiencia de apoyar a las pequeñas y medianas empresas en el emprendimiento, bajo un modelo como el de China, basado en la formación tecnológica y la capacitación masiva.





Pedaogical Innovation, Technology, Methodology

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Introduction

Digital Villages[1] (DV) is a commercial initiative belonging to the Alibaba group, a proposal of Chinese origin, distinguished for being one of the leading online wholesale markets in the world, and that has developed its own model to carry out local development policies first, in some states in China and later, in different parts of the world such as Southeast Asia and Africa (Wang, 2019; Sadok, 2021), and in 2023 in Mexico, to extend the commercial inclusion of different actors outside urban centers.

Countries such as Mexico, a member of the Pacific Alliance, have implemented similar projects, with the support of Alibaba's digital business accelerator, called Atomic88, with important results (Forbes, 2021).

2019, the first pilot of the DV project began in the city of Guanajuato, and later on in locations of the states of Puebla, Querétaro, Mexico City, Sonora and, more recently, Morelos, were added (Larios-Hernández, 2023), with the objective to promote entrepreneurship in smaller scale businesses, as well as Small and Medium Enterprises (SMEs) in Mexico, to sell their products online and accelerate their sales through the so-called Digital Villages.

The Mexican global project combines the certification of consultants, the involvement of university students, and the link with small and medium-sized companies, to propose a business model energized by platforms, Apps and e-commerce base, to be included in traditional and artisanal companies, respecting the regional heritage identity, and taking them into the digital world.

The importance of carrying out and formally recovering the project acceleration experiences in this article, responds not only to a commercial logic in the search for "a recipe" for the development of the country; Above all, it implies the possibility of analyzing innovative, multidisciplinary university training initiatives, with a global focus and future projection.

Having actively participated in the Digital Villages 2024 program, as well as the learning from the training provided by Alibaba Business School[2], the next logical step is to the share these academic exercises developed in real scenarios, giving greater meaning to teaching work and student learning.

In addition to the theoretical support on business models, e-commerce and digital marketing, the opportunity to connect with university students and real companies is invaluable, helping the businesses in their efforts to increase or ameliorate promotion, organization and/or administration needs, being crucial to be able to develop new strategies, achieve meaningful learning, promoting the development of hard and soft skills, especially those related to the development of a social commitment.

It is important to emphasize that in this article, the experiences lived in the State of Morelos, underline that around 50 teachers have participated in the 1st Certification Program in Digital Transformation and Entrepreneurship for Teachers, and close to 200 students were certified as advisors of Digital Villages methodology, collaborating with SMEs in the state.

It is important to remember that the objective of this article is to analyze the theoretical and practical characteristics of the Digital Villages project in the state of Morelos, therefore, its transformative effects on Small and Medium Enterprises should be underline, especially those collaboration strategies between academics, students, entrepreneurs using digital resources to improve their visibility and commercial development prospects, contributing to the reduction of poverty and the generation of jobs.

As well as recovering the training opportunities of Alibaba Business School at various levels, it was relevant to contribute to the reflection on the importance of learning from a model like China's Alibaba Group.

[1] The Digital Villages were initially called Tobao Villages where rural communities transformed their local economies into e-commerce initiatives.

[2] Alibaba Business School is responsible for the "Global Digital Talent" (GDT) Certification on the methodology and technology they use, focused mainly on e-commerce.

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Considering that it can be a wonderful inspiration for similar projects, especially on coaching in technologies and massive training, based on the commitment to reduce poverty and the generation of jobs, based on the hypothesis that, by developing digital skills and generating a virtuous circle between academics, university students, entrepreneurs and digital platforms, it is possible to promote economic participation of small businesses and improve their prospects for visibility and commercial development.

Finally, to understand the implications of the project, it is useful to have some background and foundations about the creation of the Alibaba initiative in China, specifically related to the Tobao Villages, and their characteristics, and also know how this project got to Mexico, and make an stop to reflect about the challenge of developing in the Mexican context, as a pioneer of the Latin American region, and in the state of Morelos, describing the methodologies and each step the project, concluding with the findings and considerations related to the learnings for the successful articulation of Digital Villages in a country with very particular characteristics and dimensions.

The Tobao Villages Borned in China

Tobao Villages (Taobao Villages -TV-) are rural communities that adopted C2C (Consumer to Consumer) e-commerce through Alibaba's Taobao platform. With this initiative, small local producers were allowed to adopt digital commerce strategies to have the opportunity to sell their products directly, avoiding intermediaries and maximizing their profits (Morales, 2024).

Born in 2003, the concept of Taobao Village emerged with the launch of Taobao Marketplace by the Alibaba Group. The meaning of Tobao in Chinese is translated as "searching treasures network", and it was the goal of Dongfeng communities, when they were established in Jiangsu, followed by other towns in Hebei and Zheijian (Morales, 2024). From that year on, small companies became familiar with the proposal, and this was refined to the form that is known today.

It is worth mentioning that the type of economy of the country, had to abruptly adopt hitherto unknown commerce systems and make a leapfrogging, going directly from cash payment systems to the use of payment through cell phones, a process that, without doubt, involved an entire revolution.

According to various sources (World Bank Group reports, 2019; Alizila, 2021; Taobao Haul (s/f). or Government of Chile, 2022), to constitute a "Taobao Village", the communities had to comply with at least three requirements:

1) Start using Taobao Marketplace spontaneously.

2) Achieve a minimum annual transaction volume of RMB 10 million; and

3) Have at least 100 active online stores or 10 percent of households participated in e-commerce.

However, in 2014, the initiative took on new dimensions when the China Rural E-Commerce Demonstration Program, known as “Rural Taobao”, was created in collaboration with the Ministries of Finance and Commerce of China, whose purpose was focused on reducing rural poverty through the promotion of electronic commerce, conceiving the modernization of local communities as necessary (Taobao Haul, s/f).

According to the report offered at the Asia Pacific meeting, and just to have an idea of the dimensions and scope of the program in China, through its financial services, were provided to 816 low-income counties, credits were granted in the amount of RMB[3] 11.2 billion.

The aid contributed to the incubation of 160 regional agricultural brands, which led to the creation of Taobao Villages and Taobao Village Clusters, grouping multiple communities under the same category, reaching more than 7 thousand in 2022 (Morales, 2024).

[3] The RMB or renminbi is the legal tender of the People's Republic of China and is issued by the People's Bank of China.

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A very important aspect about the Tobao Villages has been the impact they have had, especially in marginalized communities in a large part of the Chinese rural population, by having supported small farmers and given work to women who, through their experiences, reinforce substantially their economies. Communities have been learning and shaping their thinking towards innovative digital forms of intervention.

Box 1

Figure 1

Alibaba Group services and companies' logos
Source: Alibaba Business School 2024

As expected, through digital commerce, it was possible to reach diverse markets not only locally.

The possibility of accessing other countries has contributed to the diversification of the product offering and understanding the international market, being able to establish links not only with Asian countries and the African continent, but also to begin opening towards the thriving market like in Latin American through Mexico.

Mexico, the commercial gateway for Digital Villages in Latin America

Although Alibaba is an e-commerce, machine learning, artificial intelligence, big data and intelligent logistics company, in Mexico the operations is focused to social projects, in terms of closing the digital divide, eliminating poverty and creating opportunities for vulnerable communities through digital training.

Since the beginning of the relationship with Alibaba Group, the differences between China and Latin America became evident, from various points of view such as political and institutional aspects, economic models and cultural characteristics, but the artificers of the villages identified coincidences on the needs of rural communities with growth potential, which allowed the project leaders to think about the feasibility of the initiatives and the possibility of seeing the "glocal" [4] situations of electronic commerce in small towns in Mexico, where the contribution of the Asian giant has also been present through Alibaba (Government of Chile, 2022).

The successful commercial initiative promoted by Alibaba, was adopted as a model to carry out local development policies in some states of China, to extend the commercial inclusion of different actors outside urban centers. Countries like Mexico, a member of the Pacific Alliance, have generated similar projects with important results.

Reflecting on the case of Mexico regarding digital commerce, its constant growth has been evident, since the beginning of the second decade of this century, 6 out of every 10 Small and Medium Enterprises (SMEs) were already selling online, showing growth of 94.6% compared to the year 2020 (Forbes, 2021). It is worth to remember that the countries accelerated their digital processes due to the COVID-19 pandemic and has continued to grow due to consumers' familiarization with online purchases during health confinement. However, even though the demand for electronic commerce is estimated to be increasing in Mexico, specialists assert that only 10% of SMEs have a website and less than 3% are selling online (statements by Andrés Bedolla, representative for Mexico on Alibaba in Forbes, 2021). Regarding Digital Villages, the spearhead came in the state of Guanajuato, where the first Digital Village proposals were generated aimed at promoting artisanal products such as leather goods, typical sweets and even molcajetes, made with basalt stone, just to mention a few examples, providing encouragement to entrepreneurs, as well as SMEs in said state, to sell their products online and fast-tracking their sales through its accelerator Atomic 88.

[4] Reflecting or characterized by both local and global considerations.

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Followed by the mentioned entity, proposals emerged for the states of Puebla, Querétaro, Mexico City, Sonora, Jalisco, Chiapas, Quintan Roo and Morelos, with the expectation of achieving the digital transformation of 32,000 young people trained in digital skills and around 1,600 digitally transformed micro businesses, with the use of technology to sell better (Forbes, 2021).

Examples of the first Global E-commerce Project developed in conjunction with the Alibaba Business School in Mexico are:

Puebla: Zacatlán de las Manzanas.
Guanajuato: Footwear, caramel sauce (cajeta), and Comonfort crafts with basaltic stones.

Even though, the post-COVID economic challenges have been evident, according to Zhang Yu, Vice President of Alibaba Group, Mexican exports to China increased during the pandemic at a rate of more than 3,6% in the first five months of 2021, sample of the great resilience of bilateral relations, focusing energy on improving the commercial structure and further tightening industrial and supply chains in Mexico and China (Forbes, 2021).

Looking ahead, in 2036, Alibaba expects to serve 2 billion consumers and create 100 million jobs with its business ecosystem, and these numbers consider Latin American scenarios including Mexico, with the firm purpose of cultivating outstanding talents to help the digital transformation (Forbes, 2021) and, under the under the saying that there is no small cause, in addition to large Mexican cities such as CDMX or Guadalajara, the initiative of the state of Morelos emerged, and had culminated in the month of July 2024, and which is reported in the present research work.

Digital Villages Proudly from Morelos

The state of Morelos, Mexico, rich in history, culture and natural resources, with a diversified economy and an important tourist attraction, is in south-central Mexico, being a place that is distinguished by its great biodiversity and cultural importance. Bordering to the north and west with the state of Mexico, to the east with Puebla and to the south with Guerrero, in addition to its proximity to Mexico City, this important location is considered as strategic place in terms of commercial possibilities.

In addition to the tertiary tourism sector, the economy of Morelos is based on activities such as agriculture and the manufacturing industry, as well as the production of sugar cane, vegetables and flowers, which are very important in the agricultural sector.

A special attraction for tourism that generates significant income for the region, is the cultural richness of its communities, populated by various ethnic groups, including the Nahua and the Otomi, among others.

This diversity is reflected in the traditions, gastronomy and festivities of the state.

Just as the mentioned benefits of Morelos, even when the climate and location seem to place it in a privileged situation, it is important to mention that the agricultural economy has faced problems such as foreign competition and climatic challenges, while tourism has been affected by the criminal groups and the COVID-19 pandemic.

Violence and insecurity have been a persistent challenge in various regions of Mexico.

This has negatively affected both residents and businesses, negatively influencing investment initiatives and quality of life.

Despite having prosperous areas like Cuernavaca, Morelos, even this type of cities face socioeconomic inequality, with rural and urban areas less developed than others. This can manifest itself in lack of access to basic services, quality education and job opportunities. In fact, a significant part of the population of Morelos works in the informal sector, which can lead to precarious working conditions, lack of social security and low economic incomes.

Even though there has been investments in infrastructure in Morelos, especially in roads and transportation, there are areas that require improvement, such as water supply, educational and health infrastructure, in addition to the fact that natural disasters have occurred in the state in recent years, such as earthquakes and floods, having a significant impact on the economy and the daily lives of residents, especially in rural and less developed areas.

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Considering the aforementioned challenges of the state, a project like Digital Villages finds in the establishments of Morelos, a privileged niche to develop because, in addition to the fertility of its lands and the endemic species that characterize it, the knowledge of botany and ancestral practices, as well as the respect for the communities and the desire of its inhabitants to preserve the knowledge inherited from their ancestors, have served as an incentive and inspiration, both from the artisanal point of view and from agricultural products, herbalists, ceramics, crafts, gastronomic proposals and much more.

In the month of February 2024, the Alibaba Group, through the Association of Industrialists and Entrepreneurs of Morelos (ADIEM), established contact with educational institutions located in the state, conforming a group of 50 teachers who, on a voluntary and unpaid basis, took part on the Certification in Digital Transformation and Entrepreneurship for Teachers, with the idea of training digital experts who will serve as mentors in the second phase of the project. Among the participating institutions, the majority included teachers from the Autonomous University of the State of Morelos, also participated teachers and students from the Technological Institute of Zacatepec; Cuautla Technological Institute; The Pedagogical University of the State of Morelos; La Salle Cuernavaca; National Technological Institute of Mexico-Zacatepec; Fray Luca University; School of Higher Studies of Jonacatepec UAEM; University of the Valley of Mexico Cuernavaca Campus; UAEM Headquarters Mazatepec School of Higher Studies; Polytechnic University of the State of Morelos; and the Libertad University Center.

Box 2

Figure 2
Digital Villages Closing Ceremony 2024
ADIEM, 2024

During the virtual training sessions, academics from the participating universities delved into the characteristics of the digital economy and the new consumer; digitization of retail, logistics and finance; Artificial intelligence; Digital business model; Customer-centric products; Introduction to Digital Marketing, among other topics, which contributed to the strengthening of the mentors on the concepts stated and the understanding of methodological alternatives for the generation of case studies of digital businesses, to the accompaniment of students during their training and to the small enterprises in their orientation, as fundamental elements for the success of the project.

Each of the selected establishments constituted an inspiring example of how an enterprise can emerge from the local level, to become an important player both nationally and internationally, maintaining a strong commitment to the quality of its products, sustainability and social responsibility.

A special focus in made on the collaboration with local communities, and the selection of their local riches, reflecting a deep connection with the culture and resources of the region. The combination of pre-Hispanic traditions, colonial influences and contemporary practices in communities, provide an amusing and diverse context for business development.

Intelligent adaptation to the demands of consumers and especially of the client allows permanence in the market, through a continuous search for growth opportunities because, in the face of contingent situations such as a health emergency, companies in various areas have demonstrated their ability to innovate, and respond to changing consumer needs, even during challenges like the COVID-19 pandemic.

In the case of Digital Villages, the search for commercial success has been actively committed to social causes. by supporting local communities and promoting gender equality.

This combination of ethical values and solid business vision is essential to building a strong and sustainable brand in the long term as has been seen in recent years, as society, the market and businesses have experienced significant transformations.

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Life changes have accelerated due to several key factors such as (based on analysis by Capgemini Research Institute, 2024):

Environmental and social awareness: Society has increased awareness of environmental and social issues, which has led to a growing demand for products and companies that are environmentally friendly, ethical and socially responsible.

Changes in consumer habits: Consumers are increasingly looking for natural, organic products free of chemicals harmful to their health and the environment.

Technology and digitalization: Digitalization has transformed the way companies interact with consumers, promote their products and manage their operations.

Globalization and fair trade: Globalization has opened opportunities for companies to expand internationally and access new markets.

Society in general is evolving towards greater environmental and social awareness, which drives changes in consumer habits and expectations towards companies. This has led to increased demand for businesses and offer quality, environmentally friendly and socially responsible products, and that are adapted to an increasingly digital and globalized commercial environment.

It should be noted that, in recent years, both in the country and in the state, due to water scarcity and the growth in contaminants, more and more people have increased their environmental and social awareness.

Consumers are more interested in products that are environmentally friendly and socially responsible, considering companies that promote ethical business practices, such as fair trade and collaboration with local communities.

However, although Morelos has prosperous and attractive areas for tourism, it also faces socioeconomic challenges, such as inequality, insecurity, and vulnerability to natural disasters.

Given the intentions of international expansion and the growing demand for products for Morelos businesses not prepared for change, logistical and distribution challenges may arise, so it is important that entrepreneurs consider active and sensitive listening to the needs as a challenge community, to be able to provide with the contributions of the people who are responsible for transmitting their traditional knowledge.

Among the risks in a market like the one of the State of Morelos, where authenticity and transparency are valued by consumers, any controversy related to ethical business practices, or the quality of products can damage the reputation of companies in the long term.

It is important to consider that changes in the national or global economy affect the purchasing power of consumers and their willingness to spend on certain products, so entrepreneurs must be prepared to face economic volatility and adapt to market fluctuations, not forgetting that the various business sectors are subject to government regulations in terms of safety, labeling and manufacturing practices.

External factors such as economic crises, regulatory changes or pandemics, can have a significant impact on consumer needs and behaviors. Morelos companies that seek to adapt quickly to these changes, will be more resilient and more likely to survive and thrive in challenging environments.

In short, the adaptation of companies to the needs of consumers is essential for their success and sustainability, particularly in this sector. By understanding and responding effectively to market demands, companies can improve customer satisfaction, remain competitive, and build strong relationships with their customer base.

Methodology and Applied Instruments at Morelos Experience

Methodology combines two aspects, first the Digital Villages project, and second the complementary elements that allows to understand the way in which the research and reflection process of the project was carried out, specifically for the Morelos experience, and obeys the order in which the various stages were completed, from its dissemination campaign to its conclusion.

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The general methodological basis of the Alibaba Group initiative, for both teachers and students, is project-based learning (PBL), which allows participants to identify motivating topics, while learning curricular or co-content content, testing their skills and competencies.

The challenge of each project focuses on the real situations of the selected companies, close to their reality or environment, which arouse the interest of those involved and which also reinforce those concepts and procedures that are required to be learned within the topic of marketing and digital resources.

Box 3

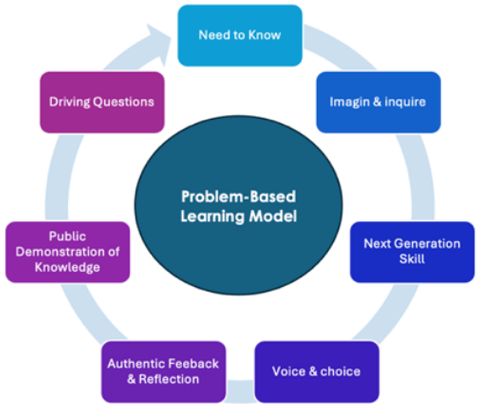

Figure 3

Digital Villages Methodology: Problem-Based Learning Model

Own elaboration considering Nilson, 2010

Through the DV project, based on PSL, the students had the opportunity to develop skills related to (Nilson, 2010):

- Working in teams.
- Managing projects and holding leadership roles.
- Oral and written communication.
- Self-awareness and evaluation of group processes.
- Working independently.
- Critical thinking and analysis.
- Explaining concepts.
- Self-directed learning.
- Applying course content to real-world examples.
- Researching and information literacy.
- Problem solving across disciplines.

In a very summary way, the academic project begins with the selection of participating students by the mentors, who register and guide the students in the process and activities that, individually or in teams, are carried out during the project.

The first activity is a diagnosis, assessing various aspects to consider throughout the project. Either collaboratively and in some segments autonomously, students, mentors and companies develop the digitalization proposal for the acceleration of the company. Finally, the final product or solution is shared and presented with the rest of the classmates, expanding the spectrum of knowledge and multiplying knowledge.

To achieve the above and in an operational manner, the following stages are covered:

Box 4

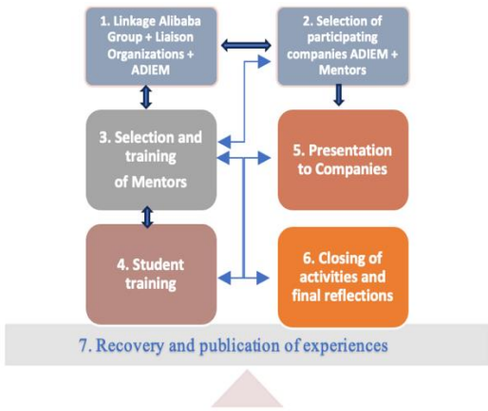

Figure 4

Stages of the Digital Villages 2024 Project.

Own elaboration, 2024

1st Stage: linking Alibaba Group + companies + private and public sectors

The triggering element of the project can be defined as the spaces for exchange and reflection of the initiatives of the Asia Pacific Economic Cooperation Forum (APEC[5]), where the Tobao Villages project was announced, which aroused great interest among the partners, especially based on APEC's mission to support economic growth and prosperity in the Asia-Pacific region.

[5] The Asia Pacific Economic Cooperation Forum (APEC) is the main forum to facilitate economic growth, technical and economic cooperation, trade and investment facilitation and liberalization in the Asia-Pacific region. Made up of 21 economies: Australia, Brunei Darussalam, Canada, Chile, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, Philippines, Russia, Singapore; Taipei-China, Thailand, the United States and Vietnam.

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In this first stage, the understanding of the concept of "Digital Village" is achieved as "a novel form of construction of modern villages that have digital and intelligent production elements, based on the Internet as operational support, and using emerging practical technologies such as the Internet. of Things, cloud computing and big data" (Zhang et al, 2023). This stage involves diplomatic ties between governments, representatives of Alibaba Group, the Association of Industrialists and Entrepreneurs of Morelos (ADIEM) and directors and rectors of universities in the state.

Box 5

Figure 5
Alibaba ADIEM Call Poster
ADIEM, 2024

2nd Stage: Selection and training of Mentors.

The next stage consists of a series of calls and presentations to involve academics from various universities and areas of knowledge so that, voluntarily, they agree to participate along with their students in the Digital Villages project. The teacher certification lasted nine weeks and the contents were divided into two large blocks: a) Digital Transformation and Digital Entrepreneurship, each section divided into weekly topics and with evaluations (Quizes) and project presentations (study case).

Box 6

Figure 6
Global Digital Talent Certificate
Alibaba Business School, 2024

The training provided, as well as the materials, were taught by an expert advisor in weekly virtual meetings and the review of materials and videos designed by Alibaba Business School specialists, requiring significant time dedication and spaces for participation and intensive studies to provide follow-up to the Digital Villages project, fulfilling Alibaba's objective of "digitizing" the teachers who would later serve as mentors for young university students.

It goes without saying that, in general, the participating teachers mostly had digital skills due to their training.

3rd Stage: selection of participating companies.

Almost simultaneously with the training, the call and presentations are launched for companies with the potential to participate, and that meet specific characteristics such as belonging to Morelos entities, with digital development needs, that offer products from the region, among others aspects, as already mentioned.

Interested companies receive a questionnaire to find out their business line, the dimensions of the venture, the people involved and relevant information to be able to define its characteristics and possibilities of intervention and the companies are assigned, sharing the information with mentors and students.

The assignment of companies is carried out with the intervention of ADIEM, who considers their profiles, especially those open to interacting with new technologies, as well as the use of tools based on Artificial Intelligence (AI).

Just as an example of the companies selected for the Morelos 2024 Digital Villages project, we can mention Lions Tours (travel club), 8treina (transformation of fused glass into art), IMEC Cuernavaca (Spanish school), among others, including crafts, typical sweets, real estate or gastronomic services, preserved products, event organizers, demonstrating that the possibilities are open for a wide spectrum of ventures that can expand their potential through not only digitalization, but also their visibility.

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4th. Stage: Student training

A fundamental part of the Digital Villages is to bring young university students closer to both certified academics and invited mentors, renowned experts in digitalization issues who, in their careers, have created companies, are project leaders or representatives of organizations. both national and international, being a great example and inspiration for the university community and giving added value to the international certification.

The selection process begins when the mentor (teacher) invites the students, both for training and for the development of the project and presentation. Each student is assigned a specific company and is provided with detailed information about it. On some occasions they work as a team, but for the Morelos version, each student got involved with a different company.

It should be added that, from the beginning, students were emphasized that the objective of the program was, above all, to promote rural or urban communities with commercial potential, but technologically lagging, through the use of digital platforms, to transform their industries and improve its commercialization, giving young university students the opportunity to acquire knowledge, tools and experience in digitalization through mentoring from experts in the field. Thus, participating students obtain:

- Free Digitalization Training
- Professional experience
- Diploma in Digital Transformation
- International Global Digital Talent Practitioner Certification.

All the above is endorsed by the Alibaba Business School as a globally recognized certification that turns out to be an asset on their resume and provides them with additional opportunities in the labor market.

As part of the methodology, each student receives a workbook with exercises and questions related to the digital transformation of the assigned company. This material is delivered in advance so that students could research and become familiar with the company assigned and the basic concepts of digital transformation. In this way, they prepare to actively participate in the training and will be able to ask any questions or concerns that arise during the session.

To begin, students attend intensive virtual training on digital transformation topics in an initial four-hour session. During this session, fundamental aspects of digital transformation will be addressed, including implementation strategies, relevant technological tools and best practices to carry out digitalization processes in the assigned companies. Subsequently, the mentors organize the individual or group sessions that are considered, to provide guidance on each project.

To obtain certification, the student must deliver the final folder to his or her teacher that contains the following:

Workbook: Complete that contains the records and activities related to the planning and execution of the digital transformation plan of your assigned company.

Executive Presentation: That includes the analysis of the current state of the company, evaluation of digital transformation needs and detailed implementation proposal.

Evidence of Implementation: Documentation that demonstrates the successful implementation of the digital transformation proposal, such as screenshots of WhatsApp Business profiles, links to documents shared on Google Drive, company location on Google Maps, screenshots of social networks created or updated, and screenshots of the online store, or product catalog, among others.

Project Evidence Photos: Photographs showing student participation in conferences, virtual training, and meetings with mentors.

5. Stage: Presentation to Companies

After the training, and once the students complete their workbook, the date is scheduled for an executive presentation that includes the diagnosis, instruments based on agile planning methodologies such as PEST (analysis of the Political, Economic, Social and Technological) CANVAS (methodology for planning based on the characteristics and needs of the client), Costumer Persona (to analyze potential clients) among other strategies, and a proposal for the implementation of digital transformation, prepared by the students and with the guidance and supervision of the certified mentor.

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6th. Stage: Closing of activities and final reflections

After finishing the workbook, the evaluation meeting is held between students and mentors, to recover the learning and define the points for improvement, presenting the results to colleagues from non-participating groups, to share what was learned.

7th Stage: Recovery and publication of experiences

The seventh and final stage is the systematic recovery of the documents and videos generated during the project, as well as the design of materials for the future replication of the methodology, both in training for teachers and in specific digital entrepreneurship courses.

Results

Among the opportunities to be considered is the incorporation of a digital strengthening model for companies that contemplates adapting to the needs of consumers, being based on their tastes and preferences, taking into account the conditions that constantly evolve due to factors such as demographic changes, cultural influences and technological developments, therefore, it is worth remembering that in a competitive market, companies that do not adapt to the needs and desires of consumers run the risk of losing market, especially to competitors that offer products and services more aligned with the demands of the target audience.

Whether large-scale businesses or small and medium-sized establishments, customer satisfaction is essential for the long-term success of any endeavor. Adapting to consumer needs helps to ensure that the products and services provided, meet client expectations, which can lead to greater customer loyalty and retention.

Adaptation to consumer needs encourages innovation in products and services. As companies that are in tune with market demands are those that can identify new opportunities and develop innovative solutions that differentiate themselves from the competition, demonstrating genuine commitment.

Just as part of the results, the authors participating in the research, carried out the digitalization of eight companies related to recycling, provision of services, rental of real estate, crafts and gastronomic products, but the cohort of professors of all the universities, in the sum, served around 200 students and a similar number of companies, managing to institutionally generate various initiatives and some written works. As it was possible to observe, technological improvements are an integral part of modern life, since they seek to optimize and facilitate various activities. These improvements have not been limited to the physical world, but also extend to the digital sphere and, incidentally, to institutional culture and society.

Regarding the technological aspects, it is mentioned that software plays a crucial role in this process, by allowing the incorporation of efficient processes and optimized workflows.

The phenomenon of incorporating technology sources is known as digital transformation, which involves adopting and leveraging digital technologies to improve the way tasks are performed and processes.

Digital transformation seeks to use technology to optimize and improve efficiency in various areas of life and work, involving a series of initiatives aimed at modernizing and optimizing its operations and services using digital technologies. Some possible areas of focus for this transformation that emerged from working with companies were:

Improved online presence: Proposal to develop a more robust and user-friendly website, to allow customers to easily explore and purchase products from any device.

E-commerce: Proposals for the implementation of electronic commerce platforms that allow customers to make purchases online in a convenient and secure manner. This would include the integration of electronic payment systems and logistics for the delivery of products such as:

PayPal: as a very practical online payment method that allows you to associate credit cards with a PayPal account and, when you want to pay, simply log in with an email and password and choose the card you want to use to make the payment.

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Payment Market: so that customers can pay with credit cards, bank transfer and even cash. At the same time, in addition to simplifying collections, it provides your clients with access to promotions and financial services without commissions or extra expenses and without risks of any kind.

Kueski Pay: which is a solution that gives customers the possibility of financing their purchases in a store without depending on a credit card. By choosing Kueski Pay as your payment method, you give yourself the opportunity to buy now and pay later, with access to interest rates and terms that suit customers' needs.

Mobile applications: Proposals for the development or use of mobile applications that offer customers a personalized experience, such as instant resolution of doubts through WhatsApp.

Inventory management: where it is proposed to implement digital systems for efficient inventory management, allowing real-time monitoring of stocks and timely replenishment of products.

Digital marketing: such as social media marketing Facebook, Instagram, online advertising and email marketing, to reach new customers and maintain engagement with existing ones.

Process automation: incorporating automation tools to streamline internal processes, such as order management, customer service and accounting data analytics – to better understand customer behavior, identify market trends, and make informed decisions to improve operations and customer experience.

Collaboration with e-commerce partners: By partnering with emerging companies and taking advantage of the e-commerce services they offer, managing to accelerate and promote their leading products today in e-commerce such as: Mercado Libre, Amazon and Privalia.

All the resources have been proposed to ensure effective integration between physical and digital channels, to provide a consistent and seamless experience at all customer contact points.

In other words, it highlights the need for the consumer experience to be consistent, regardless of whether they interact with a company through its physical stores, its website, its mobile applications or other digital means. This consistency in the client experience is crucial to maintaining customer satisfaction and strengthening the relationship with the brand.

Transformation through Digital Villages involves adopting digital technologies in all business areas to improve operational efficiency, strengthen customer relationships and remain competitive in the market.

Finally, within the findings, the convenience of incorporating the Market Shops (Mercado Shops) platform was assessed, which is an e-commerce platform provided by Free Market (Mercado Libre), one of the main e-commerce companies in Latin America.

This platform allows companies to create and manage their own online stores in a simple and efficient way, providing the following opportunities to generate greater diversity in the digital business. Some key features and functionalities of Mercado Shops include:

Store Customization: Allows businesses to customize their online store with their own branding, logo, colors and design, helping to create a consistent and engaging shopping experience for customers.

Product Management: Allows sellers to easily and efficiently upload and manage their products, including creating detailed descriptions, setting prices, managing inventory, and organizing into categories.

Integration with Mercado Pago: Mercado Shops is integrated with Mercado Pago, Mercado Libre's online payment system, allowing customers to make payments securely and conveniently using a variety of payment methods, such as credit cards, debit cards, bank transfers and cash.

Order Management: Facilitates order and shipping management, allowing sellers to track orders, manage order fulfillment, and provide shipping updates to customers.

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Customer Support: Offers tools to provide efficient customer service, such as managing queries and complaints, communicating with customers through direct messages, and resolving issues in a timely manner.

Ease of Use: Mercado Shops is designed to be easy to use, allowing businesses to create and manage their online store without requiring advanced technical knowledge. The intuitive interface guides users through the process of setting up and managing the store easily.

Adaptability: The platform adapts to the needs of different types of businesses, from small businesses to large corporations. Offers customization options so that each store reflects the company's identity and brand.

Security: Mercado Shops offers a secure environment for online transactions. Integration with Mercado Pago ensures that payments are secure and protected against fraud.

Visibility: By being integrated with Mercado Libre, the online store created in Mercado Shops can take advantage of the massive audience of buyers who visit Mercado Libre daily. This increases the visibility of products and can generate more sales for companies.

Analytics: The platform provides analytics tools that allow businesses to track the performance of their online store. This includes data on sales, web traffic, customer behavior and more, helping you make informed decisions to improve your business.

Support: Mercado Shops offers technical support and customer service to help companies resolve any problems or questions they may have while using the platform.

And finally, the most relevant aspect of all, was the mobilization of human capital, mentors, university students, companies, representatives of organizations and much more, willing to contribute to a common cause for their own benefit and that of the communities, recovering regional wealth and pride of belonging.

Achieving real learning, with meaning in life and application in the short, medium and long term, has been a trigger for future initiatives that, in addition to a digital transformation, contribute to the strengthening of a society that needs hope and a sense of direction.

In a very summary way, all the companies involved in the Digital Villages project were able to establish strategies proposing the incorporation of useful sales tools through applications or platforms, considering greater growth in the digital space and participants at all levels have incorporated to their learning a new know-how, knowing how to be and be, fundamentals of this century professionals.

Special thanks

Secretariat of Economic Development and Labor of the State of Morelos (SDEyT), Association of Industrialists and Entrepreneurs of Morelos (ADIEM Morelos), Alibaba Group and Alibaba Business School, Participating Companies, especially those belonging to Orgullo Morelos (Morelos Pride), Andrés Díaz Bedolla, Co- Founder & CEO @ Yumari, former founder and CEO of #ATOMIC88 and head of mentor training.

Irasema Rodríguez Rojas, ADIEM Administrative Assistant. Sofía Garrido, Academic Coordinator of Digital Villages.

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Conclusions

The research and recovery on Digital Villages has allowed, in the first instance, to determine the relationship between digital resources and economic or social entrepreneurship through e-commerce based, above all, on the growing interest in technologies, the expansion of commerce electronic and online sales, as a means that can provide companies with the opportunity to reach a broader market, even internationally.

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Engaging with mentors and advisors and collaborating with local communities to source regional products and support fair trade practices can strengthen relationships with local suppliers and promote sustainable development.

Continued commitment to social responsibility and ethical business practices can differentiate the market, attracting consumers who value the positive impact of their purchases.

Expansion to international markets, where there is a growing demand for natural and organic products, can be an opportunity to reach new customers and strengthen its global presence, having a promising future based on the commitment to quality, sustainability and social responsibility.

Finally, even though it was found, through the project, that some of the companies already worked with digital resources, they did not do it in a very systematic way or as a comprehensive strategy, so the final recommendations for all the companies with which we worked would be:

An improved online presence that includes or continues the development of your website with a view to developing robust and user-friendly environments and emphasizing the most in-demand products.

And Regarding e-commerce options, consider means such as PayPal, Mercado Pago, credit or debit cards, in addition to suggesting mobile applications to strengthen your presence in digital marketing and continue collaborating with e-commerce partners.

Finally, in addition to the commercial recommendations, the most important spirit of the entire project is the understanding of how to support and generate real and innovative conditions so that both academics, students, and even companies, envision authentic projection scenarios, knowing that technologies are powerful means, but the end is even more so, and this is to contribute to the quality of life, empowerment, the growth of society with justice and of course finding happiness and pride in entrepreneurship.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Authors' contribution

Juarez-Salomo, Norma Angélica: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Display, Original draft writing

Silveyra-Rosales, Mariana Teresa: Conceptualization, Formal analysis, Investigation, Methodology, Validation.

Cuevas-Olascoaga, Miguel Ángel: Conceptualization, Data curation, Investigation, Methodology.

Gama-Hernández, Gerardo: Project administration, Resources, Software, Investigation, Methodology.

Availability of data and materials

All the data obtained in this research is available.

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Secretariat of Economic Development and Labor of the State of Morelos (SDEyT), Association of Industrialists and Entrepreneurs of Morelos (ADIEM Morelos), Alibaba Group and Alibaba Business School.

Abbreviations

ADIEM: Association of Industrialists and Entrepreneurs of Morelos

DV: Digital Villages

SDEyT: Secretariat of Economic Development and Labor of the State of Morelos

UAEM: Autonomous University of the State of Morelos.

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https://doi.org/10.35429/JTE.2024.8.20.2.15

References

Background

Alizila (2021). *Alibaba Lowers Barriers for Merchants on Tmall and Taobao***.** Alizila: News from Alibaba.

Morales-Estay, Pablo (2024). *From Tobao Villages to Digital Villages***.** Asia Pacific Program. Library of the National Congress of Chile.

Wang, Jing (2019). *Taobao Villages Driving "Inclusive Growth" in Rural China***.** Alizila: News from Alibaba.

Zhang P, Li W, Zhao K, Zhao Y, Chen H, Zhao S (2023) *The Impact Factors and Management Policy of Digital Village Development: A Case Study of Gansu Province, China.*

Basics

Taobao Haul (s/f). *¿Qué es Taobao? El gigante E-commerce Asiatico.*

Support

Forbes (2021). *Guanajuato leads the creation of 'digital villages' in Mexico.*

Government of Chile (2022) *We launched the Zero Digital Gap Plan so that everyone has access to connectivity regardless of where they live.*

Nilson, L. B. (2010). *Teaching at its best: A research-based resource for college instructors (2nd ed.).* San Francisco, CA: Jossey-Bass.

Differences

Larios-Hernández (2023). *Alibaba in Mexico: Adapting the Digital Villages Model to Latin America.*

Discussions

Capgemini Research Institute (2020) *Consumer Products and Retail: How sustainability is fundamentally changing consumer preferences.* Capgemini Research Institute Analysis.

Sadok, Hicham, 2021. *How can inclusive growth be enabled from financial technology?* HomeInternational Journal of Business Performance Management. Vol. 22, No. 2-3. July 16, 2021. pp 159-179.

World Bank Group (2019). *E-commerce Development: experience from China.*

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Article

Supported learning in STEAM and PBL methodology; Using 3D CAD Software for the mechanical design of sumo robot

Aprendizaje sustentado en metodología STEAM y ABP; empleando software tipo CAD 3D para el diseño mecánico de un robot sumo

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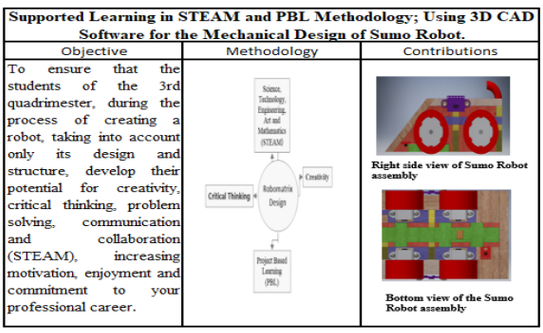
Abstract

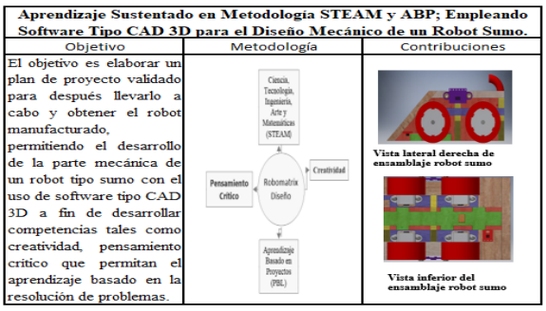
The objective of this work was to ensure that the students of the 3rd quadrimester, during the process of creating a robot, focusing only on its design and structure, develop their potential for creativity, critical thinking, problem solving, communication and collaboration (STEAM), increasing motivation, enjoyment and commitment to your professional career. The creation of the mechanical design, supported by the rules of participation for the Robomatrix competition, was carried out through the application of knowledge, skills, tools and techniques applicable to the methodology based on the disciplines: science, technology, engineering, art and mathematics (STEAM).), with the focus on problem solving through Project-Based Learning (PBL) and the use of CAD-type design software; in addition to physical resources, materials, equipment, software, licenses, etc. As a result, the mechanical design of the structure of a sumo robot was obtained, for which the manufactured parts were assembled according to the design and functional tests were carried out. It was evident that the development of experiences in the area of robotics have allowed the participating students to improve their performance by an approximate percentage of 18%, mainly due to the development of creativity, responsibility and social leadership.



Educational Robotics, Mechatronics, STEAM

Resumen

El objetivo del presente trabajo fue lograr que los estudiantes del 3° cuatrimestre durante el proceso de elaboración de un robot, atendiendo solamente su diseño y estructura, desarrollen su potencial de creatividad, pensamiento crítico, resolución de problemas, comunicación y colaboración (STEAM), aumentando la motivación, disfrute y compromiso con su carrera profesional. La creación del diseño mecánico, sustentado en las reglas de participación para la competencia Robomatrix, se realizó mediante la aplicación de conocimientos, habilidades, herramientas y técnicas aplicables a la metodología basada en las disciplinas: ciencia, tecnología, ingeniería, arte y matemáticas (STEAM), con el enfoque de resolución de problemáticas a través del Aprendizaje Basado en Proyectos (ABP) y el uso de software de diseño tipo CAD; además de recursos físicos, materiales, equipos, software, licencias etc. Como resultado se obtuvo el diseño mecánico de la estructura de un robot sumo, para el qué se ensamblaron las piezas manufacturadas de acuerdo con el diseño y se realizaron las pruebas de funcionamiento. Se logró evidenciar que los desarrollos de experiencias en el área de robótica han permitido que los estudiantes participantes, mejoren su desempeño en un porcentaje aproximado del 18%, debido principalmente al desarrollo de creatividad, responsabilidad y liderazgo social.



Robótica Educativa, Mecatrónica, STEAM

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Introduction

In the design and structure part, specifically the physical part, which is what supports the electronic section such as cards, sensors and motors, meaning the body and mechanical parts.

For his educational practice, the teachers seek to ensure that students learning is effective, motivating and meaningful, promoting the formation of technical, natural and social competencies, allowing the development of systemic thinking, promoting the realization of all dimensions of the educational process (Ruiz and Sánchez, 2011, Bers, Seddinghin and Sullivan, 2013; Sánchez Tendero, Cózar Gutiérrez, and González Calero Somoza, 2019)

Benefits have been observed in the ability to solve problems (Siago, Arnau and González-Calero, 2018), teamwork and spatial skills (González-Calero, Cózar, Merino and Villena, 2018), among others.

The approach of integrating knowledge, tools, techniques, among others, aims to achieve a interactive and attractive experience, where new knowledge can be built while technological skills are induced (Benitti, 2012)

Finally, the principles of globalization, socialization and gamification must be kept in mind. Thus, the idea of the Project arises, derived from the didactic utility as a result of the construction of a Sumo Robot (Barrera Lombana, 2015; Valencia-Rodríguez, Zegarra, and Rivera-Delgado, 2020).

Remember that Sumo Robot are similar in their physical appearance to a toy car measuring no more than 30 cm wide by 30 cm long and weighing no more than 1.5 kg in the case of the Light Sumo Robot, in the case of the Heavy Sumo Robot 3 kg. All feature is based on C.E.R. specifications, 2012.

The purpose of these robots is to participate in a fight, which takes place in a ring called Dohyo.

The robots are autonomous, that is to say, they perform alone according to the programming on their electronic cards, being able to solve the Dohyo in the state they are in and attack their opponents.

Sumo Robots consist of three sections, which are specified as:

Hardware, Software, Design and structure (Lindao-González and Quilambaqui-Mayorga, 2014)

The importance of this research is based on the creation of value, allowing a comparison to be established between the modular and the theoretical, in a niche of specific needs, coupled with the generation and/or improvements to the capacity for associative work in order to improve conditions social and economic of the region.

The objective of this work was to ensure that the students of the 3rd quadrimester, during the process of creating a robot, taking into account only its design and structure, develop their potential for creativity, critical thinking, problem solving, communication and collaboration (STEAM), increasing motivation, enjoyment and commitment to your professional career.

In the first section of the work, the literature review, the conceptual framework and STEAM methodology are presented, as well as the review of the work concerning the design and construction of the Sumo Robot.

The second section describes the methodology used, followed by sections on analysis of results, discussion, conclusions and limitations, as well as proposals for future research work.

Contextual Framework

Robotics is an applied physical science, whose goal is the design, development, operation and application of robots in different activities. The design of a robotic system incorporates principles of mechanical electronic, computational engineering and artificial intelligence.

Throughout history, robotics imitates human behavior in order to manage tasks in a similar way. It should be mentioned that, many robots perform jobs that are dangerous for people, such as defusing mines, firefighting, remediating nuclear contamination, reactor decommissioning, tunneling, underwater engineering or shipwrecks (Yang and col., 2022).

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Robotics has great potential as a multidisciplinary tool, enabling students to have a practical experience of the scientific method, through the construction of prototypes, which allow a holistic vision in the learning processes and pose the challenge of integrating the virtual with the objects themselves (Niño and Fernández, 2019; Jiménez Castro, Cerdas González, 2014).

Educational robotics constitutes a form of learning whose purpose is the design and construction of experimental prototypes with creativity and originality, involving a problem-solving process in order to develop systematic, structured, logical and formal thinking (Ruiz and Sánchez, 2011; Lopes and Guedes, 2016; Martínez, Escamilla, and Campos, 2019).

Methodology

The first approach consisted of developing a validated project plan and then carrying it out and obtaining the manufactured robot, allowing the development of mechanical part of sumo-type robot with the use of 3D CAD-type software (Restrepo-Echeverri, Branch-Bedoya, and Jiménez-Builes, 2022).

Cost-management includes the processes necessary so that the sumo wrestler robot project can be completed within the initially agreed budget.

Considering as inputs, for Project management, the application of knowledge, skills, tools and techniques to meet the established requirements, in methodology based on the following specific disciplines: science, technology, engineering, art and mathematics (STEAM); in addition to physical resources: materials, equipment, software, licenses, etc.

Taking into account for the construction of the sumo robot, the approach to problem solving through tools such as Project Based Learning (PBL), for creating the design supported by the rules of participation for the Robomatrix competition, seeking to encourage students to development of creativity, analysis, design and production skills following the Sumo Regulation to create a conceptual idea and continue as follows:

1. Work breakdown structure: classifies the tasks to be performed into partial projects and work packages.
2. Project planning: establishes deadlines, with start and delivery dates, for the different work packages. It must be kept in mind that the Sumo wrestling robot must be autonomous, it cannot be connected to an external device such as a computer, power supplies or any other device, nor can it have wired or Wireless communication with any external device, avoid divisions in several parts or deploy elements that are physically attached to it, during the course of the competition; emphasizing the fact that its activation must be immediate.

   The robot must have space for the name on its front, as well as a space to place the registration decal, the front cannot be white.

3. Project management plan: includes the Project structure plan, Project planning through a sketch with measurements and mechanical modeling of the parts that are going to be incorporated into the system in order to optimize the space in which the components will be placed, taking into account the characteristics of the part and/or components applicable to the development of the electronic phase, for which it is convenient to carry out simulations in 3D CAD type design programs (Figure 1).

These software allow the incorporation of electronic systems, mechanical, sensors, cabes, batteries and other integrated circuit that are in the libraries.

4. Manufacturing and assembly testing: Each part and/or component varies in its operation, depending on the assigned configuration, so they must fit together perfectly according to the mechanical design in order to achieve a consistent and robust model.

Below is the flow chart with the breakdown of the Project:

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Box 1

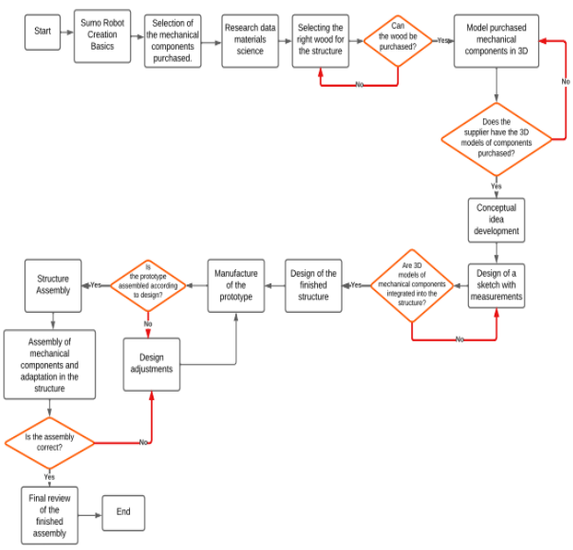


Figure 1

Structure or Breakdown of the process

Results

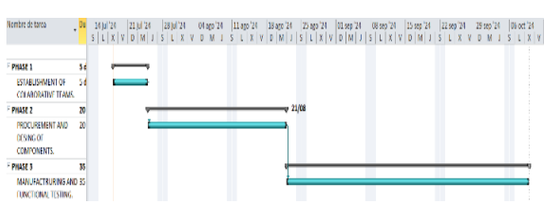
The students made use of knowledge, skills, tools and techniques, presented their conceptual Project idea in response to the requirements established for the creation of the design supported by the rules of participation for the Robomatrix competition, as well as the methodology based on the disciplines following specific áreas: science technology engineering, art and mathematics (STEAM); in addition to physical resources: materials, equipment, software, licenses, etc. Taking into account the problem-solving approach for the construction of the Sumo Robot.

1. Staged work breakdown structure:

It began with the establishment of collaborative teams, followed by the Acquisition and Design of components, to end with Manufacturing and functional testing.

2. Project Planning:

The following Gantt chart shows the stages and times required for its development.



3. Project Management Plan:

Project structure, mechanical modeling and incorporation of parts and/or components. For the Project and taking into account the appropriate specific characteristics, in order to favor execution, taking care of the risks involved documented in the failure log and prioritizing the creation of value; the following structural planning is proposed.

Box 2

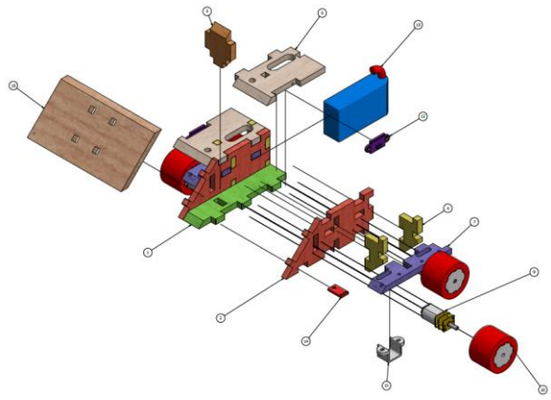


Figure 2

Exploded view of the prototype or Project

The exploded view is, as we now, a type of technical drawing, useful in the assembly of materials and is created by combining assembly files.

Box 3

Table 1

List of correlated parts in the exploded view

ELEMENT	QUANTITY	NUM. OF PIECE
1	1	ESQ 002
2	2	ESQ 001
3	1	ESQ 003
4	4	ESQ 004
5	1	ESQ 005A
6	1	ESQ 005B
7	1	ESQ 006A
8	1	ESQ 006B
9	4	ENGINE_POLOLU_6V_HP
10	4	WHEEL
11	4	CLAMP
12	3	ULTRASONIC SENSOR
13	1	BATTERY
14	1	OPTICAL SENSOR
15	1	ESQ 008

Below are different angles of the mechanical design of the Sumo Robot:

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Box 4

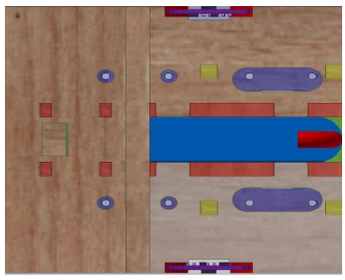

Figure 3
Top view of Sumo Robot assembly

Box 5

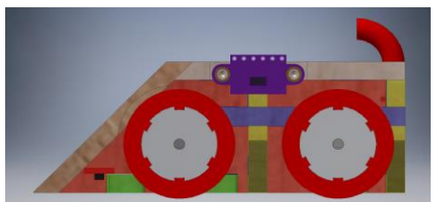

Figure 4
Right side view of Sumo Robot assembly

Box 6

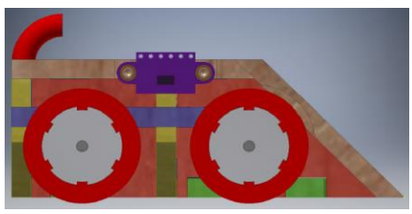

Figure 5
Left side view of sumo robot assembly

Box 7

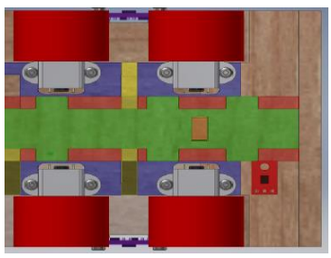

Figure 6
Bottom view of the Sumo Robot assembly

4. Manufacturing and assembly testing:

a. The students identified the bases of the competition: dimensions of 100 mm long by 100 mm wide, wooden structure, autonomous movement, maximum weight 500g.

b. They bought the materials and components: engine, wheels, rims, sensors, cables, screws, wood, performing functional tests.

c. They identified the modeled components provided by the suppliers.

d. They designed the modeling of the components that were not provided by the suppliers, and They designed the pieces that made up the prototype base on a sketch of the initial idea.

e. They adjusted the dimensions and mechanical layout of spaces for the components in the design of the prototype structure.

f. They carried out assembly test in the 3D design (Pérez Niño and Fernández, 2020).

g. They investigated the tolerances for the manufacturing of the parts that make up the prototype,

h. They made adjustments to the design measurements for efficient manufacturing.

i. Some parts were physically manufactured to verify correct assembly.

j. They established a log to record assembly and/or design failures for corrections.

k. Made design corrections for the functional structure.

l. They carried out the manufacturing of all the parts that make up the prototype.

m. They assembled the manufactured parts according to the design made to carry out functional tests.

The manufacturing of the robot was carried out as part of the academic recreational activities in support of teaching work.

On the other hand, it is worth highlighting the importance of the development of skills such as practice and creativity, which allows them to enhance their professional skills analysis, design and productions through the STEAM methodology.

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Taking into account the interrelation of the knowledge acquired by the student during their academic stay and the use of CAD-type design software, as part of the commitment to face academic challenges that seem attractive to them, with the appropriate resources and guided by the teacher and motivated to achieve their academic goals.

Conclusions

It was developed from the mechanical design of the structure of a Sumo Robot using STEAM methodology and mechatronic engineering.

Being a teaching tool that involves the use of new technologies, its implementation in a creative and effective way can be done with a minimal investment.

It was evident that the development of experiences in the area of robotics has allowed the participating students to improve by a percentage greater than 18% mainly due to the development of responsibility and social leadership, so that students in the first quadrimesters advance in topics of higher levels, being a competitive advantage for them, when carrying out consistent courses.

As future lines of research, it is proposed to evaluate various forms of work that involve the convergence between digital technologies and the hardware itself delving into precision improvement processes in mechatronic engineering at the same time.

The number of experiences described in university laboratory contexts is still limited and they are useful in contexts of exploration and problem solving that are part of teaching in STEAM disciplines, therefore, the present study is not free of limitations, due to Because the selection of articles was carried out taking into, account the topic of Robotics, consequently the data derived from the analysis must be treated with caution.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Peña-Montes De Oca, Adriana Isela: Contributed to the management of economic resources for carrying out research and publication, as well as such translation into English in the presentation of the article, academic coordination with professors, data analysis and review of the article.

Gallardo-De La Rocha, Alfonso: Contributed to the project idea, research method and academic coordination with teachers, data analysis and review of the article.

Hernandez-Hernandez, Adriana Janette: Contributed to the management of economic resources to carry out research and publication, academic coordination with teachers, data analysis and review of the article.

Availability of data and materials

The authors may make unshared data used to generate the results reported in the article available to interested parties upon request.

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References

Introduction

Barrera Lombana, N. (2015). Uso de la robótica educativa como estrategia didáctica en el aula. Praxis & Saber, 6(11), 215-234. ISSN: 2216-0159.

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A systematic review. Computers & Education, 58(3), 978-988.

ISSN: 2523-2460.
RENIECYT-CONAHCYT: 1702902

Bers, M., Seddighin, S. & Sullivan, A. (2013). Ready for Robotics: Bringing together the T and E of STEM in early childhood teacher education. Journal of Technology and Teacher Education, 21(3), 355-377. Waynesville, NC USA: Society for Information Technology & Teacher Education.

González-Calero, J. A., Cózar, R., Villena, R., & Merino, J. M. (2018). The development of mental rotation abilities through robotics-based instruction: An experience mediated by gender. British Journal of Educational Technology. Advance online publication.

Ruiz, E., & Sánchez, V. (2011). *Educatrónica*. Díaz de Santos.

Valencia-Rodríguez, B., Zegarra, H., and Rivera-Delgado, D. (2020) Construcción de experiencias de aprendizaje en robótica educativa, para alumnos de secundaria basadas en gamificación e integración de tecnologías de la información y la comunicación.

Lindao González, J. S., & Quilambaqui-Mayorga, E. H. (2014). Diseño y Construcción de 2 Robots Sumo para las categorías pesado y liviano y un Robot seguidor de línea modalidad velocidad (Ingeniero Electrónico con Mención en Sistemas Computacionales). Universidad Politécnica Salesiana Sede Guayaquil. pp. 71 y 126.

Contextual Framework

Niño J. y Fernández, F. (2019). Una mirada a la enseñanza de conceptos científicos y tecnológicos a través de material didáctico utilizado. *Revista Espacios.* 40(15), 4.

Lopes, A., Lopes, F. y Guedes, M.C. (2016). Experiencias de robótica educativa. Revista Internacional de Tecnología, Ciencia y Sociedad, 4(2), 193-204. ISSN 2174-8985, Common Ground España. Retrieved on June 14, 2024

Martínez, E., Escamilla, D. and Campos, A., (2019). Industry 4.0 and the digital transformation. A new challenge for higher education. ECORFAN Journal-Republic of Paraguay, 5(9), pp. 13-19.

Ruiz, E., & Sánchez, V. (2011). Educatrónica. Díaz de Santos.

Yang, S. Zhong, Y. Feng, D. Yi Man Li, R. Shao, X. Liu, W. (2022) Robot application and occupational injuries: Are robots necessarily safer?, Safety Science, (147) ISSN 0925-7535.

Methodology

Restrepo-Echeverri, D., Branch-Bedoya, J.W. and Jiménez-Builes, J. (2022). Educación 4.0: integración de robótica educativa y dispositivos móviles inteligentes como estrategia didáctica para la formación de ingenieros en STEM.. DYNA, 89(222), pp. 124-135, Special engineering education Retrieved on June 14, 2021.

Results

Pérez, G. Niño, J. y Fernández, F. (2020). Estrategia pedagógica basada en simuladores para potenciar las competencias de solución de problemas de física. *Aibi, Revista de Investigación, Administración e Ingeniería*, 8(3), 17-23.

Supports

Bers, M., Seddighin, S. & Sullivan, A. (2013). Ready for Robotics: Bringing together the T and E of STEM in early childhood teacher education. Journal of Technology and Teacher Education, 21(3), 355-377. Waynesville, NC USA: Society for Information Technology & Teacher Education. Retrieved on June 14, 2024.

Diago, P. D., Arnau, D., & González-Calero, J. A. (2018). La resolución de problemas matemáticos en primeras edades escolares con Bee-bot. *Matemáticas, educación Y Sociedad*, *1*(2), 36–50. Retrieved on June 14, 2024.

González-Calero, J. A., Cózar, R., Villena, R., & Merino, J. M. (2018). The development of mental rotation abilities through robotics-based instruction: An experience mediated by gender. British Journal of Educational Technology. Advance online publication.

Castro, M. (2014). La robótica educativa como agente promotor del estudio por la ciencia y la tecnología en la región atlántica de Costa Rica. *Revista de Investigación en Educación, 1*(1), 1-12.

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RENIECYT-CONAHCYT: 1702902

Lindao González, J. S., & Quilambaqui-Mayorga, E. H. (2014). Diseño y Construcción de 2 Robots Sumo para las categorías pesado y liviano y un Robot seguidor de línea modalidad velocidad (Ingeniero Electrónico con Mención en Sistemas Computacionales). Universidad Politécnica Salesiana Sede Guayaquil. pp. 71 y 126.

Sampieri, R., Fernández, C., and Batista, M. (2014). Metodología de la Investigación (Sexta Ed.). México D.F. Retrieved on June 14, 2024 from: Metodología de la Investigación SAMPIERI.pdf

Sánchez Tendero, E., Cózar Gutiérrez, R., González Calero Somoza, J.A. (2019) Robótica en la enseñanza de conocimiento e interacción con el entorno. Una investigación formativa en Educación Infantil. Revista Interuniversitaria de Formación del Profesorado, (33) 1 pp. 11-28.

Valencia-Rodríguez, B., Zegarra, H., and Rivera-Delgado, D. (2020) Construcción de experiencias de aprendizaje en robótica educativa, para alumnos de secundaria basadas en gamificación e integración de tecnologías de la información y la comunicación.

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Article

Proposal for student entry profile into software projects under the ISO/IEC 29110 standard

Propuesta de perfil de ingreso de estudiantes a proyectos de software bajo la norma ISO/IEC 29110

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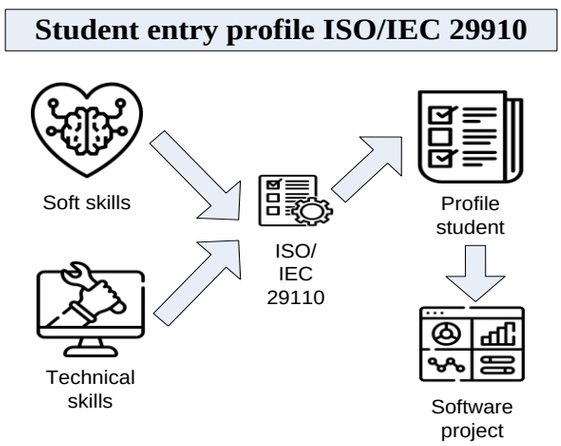
Abstract

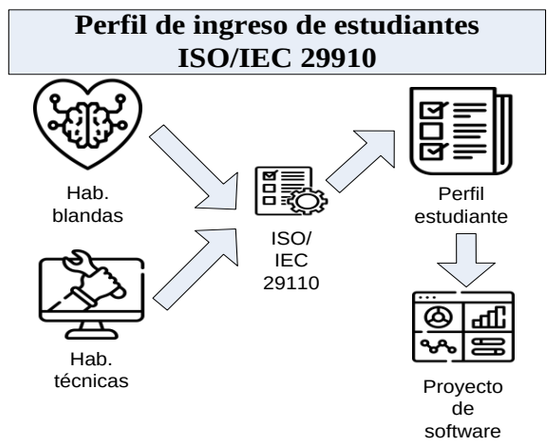
This article presents a profile of minimum desirable competencies that engineering students should meet when developing software projects within the ISO/IEC 29110 standard. Starting by presenting related works on skills and attitudes in software development, a literature review is made on the key skills of software engineers and these key skills are mapped to the roles of the work team of the ISO/IEC 29110 standard. Finally, the desirable soft skills and technical skills for students who will join work teams under the ISO/IEC 29110 standard are shown.



Skills, software engineering, ISO/IEC 29110

Resumen

Este artículo presenta un perfil de competencias mínimas deseables con las que los estudiantes de ingeniería deben de cumplir en el desarrollo de proyectos de software, enmarcados dentro del estándar ISO/IEC 29110. Inicia presentando los trabajos relacionados sobre las habilidades y actitudes en el desarrollo de software, se realiza una revisión de literatura sobre las habilidades clave de los ingenieros de software y se mapean dichas habilidades clave con los roles del equipo de trabajo de la norma ISO/IEC 29110, por último, se muestran las habilidades blandas y habilidades técnicas deseables para los estudiantes que se incorporarán a equipos de trabajo bajo la norma ISO/IEC 29110.



Habilidades, ingeniería de software, ISO/IEC 29110

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Introduction

According to (Colomo-Palacios et al., 2013) in software development, human resources are an important element, since it involves collaboration to develop them. Currently, developing the key competencies of software engineers is essential to develop products. quality and be competitive in the professional and work field.

Accelerated technological advancement and growing demand in the software industry have driven the need to train highly qualified engineers who not only master technical skills, but also possess soft skills critical for teamwork and project management.

In this context, the adoption of international standards such as ISO/IEC 29110 in the educational field has become a key strategy to prepare software engineering students, allowing them to acquire the necessary skills to face the challenges of the global labor market.

This article explores the integration of ISO/IEC 29110 into software engineering training programs, highlighting the essential technical and soft skills that students must develop to be competitive in the industry.

The main objective of this study is to identify and analyze the key competencies that should be instilled in future software engineers, as well as to evaluate the effectiveness of the ISO/IEC 29110 standard in improving the educational process and in preparing students for the labor market. Through an exhaustive literature review and analysis of previous experiences in the implementation of this standard, we seek to provide practical recommendations to optimize software engineering training programs.

Reference framework

Background of the ITSZN development center

The Instituto Tecnológico Superior Zacatecas Norte (ITSZN) is a higher education institution committed to training professionals with a high degree of quality and competitiveness. In the Computer Systems Engineering degree, study plans and programs have been implemented according to the new technological and methodological trends in Software Engineering.

In 2015, derived from the need to train students in relevant skills, knowledge and attitudes in the work environment of the software industry, the Software Development Center (SDC) was formalized, through the collaboration of professors in the area, with experience in both teaching as in the industry, and the objective of developing software projects for the institute itself was achieved.

Role of the ISO/IEC 29110 standard in the training of engineers

According to an analysis on the transition of international software standards to academic programs in Mexican universities (Muñoz et al., 2019), the MoProSoft standard and the ISO/IEC 29110 standard were compared with the curricula of 4 universities and the experience of their Software Development Centers (SDCs), it was concluded that ISO/IEC 29110 is more appropriate to transfer best practices in the software industry in small organizations, through the participation of real projects, the acquisition of new knowledge for development and software management with a quality approach.

Additionally, it allows you to obtain the benefits of using an international quality standard such as: increasing your market perspective, being more competitive, obtaining better customer satisfaction and promoting better qualified professionals.

In an experimental case carried out in the Student Wellness Center of a university in Ecuador (Castillo-Salinas et al., 2020), where 4 development teams were involved, made up of 25 Systems Engineering students, they were assigned a project Under the SCRUM methodology, better performance was observed in the testing and delivery phases in the teams controlled under the ISO/IEC 29110 standard.

Additionally, the students perceived that the standard provided a broader perspective on software projects beyond just write code.

They concluded that ISO/IEC 29110 could give a competitive advantage in the software industry and would provide new perspectives in the national and international market.

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Soft and technical skills in software development

In the Unified Competence Gate for Software Professionals (UComGSP) proposal (Assyne et al., 2022), 62 technical competencies and 63 soft competencies were identified, with 25 essential competencies for the performance of roles based on the SWEBOK.

Among the essential competencies were identified (1) new idea promotion, (2) business knowledge (3) experienced designer, (4) knowledge of industry standards, (5) mathematical knowledge in core sciences subject (6) coding competencies across platforms, (7) best practice and standard skills, (8) write test code (9) electronics and mechanics skill (1) communicate to the outside world, (2) sociable,(3) knowledge transfer, (4) see the bigger picture, (5) leadership skills (6) humbleness, (7) customer awareness, (8) understand customer needs (9) unafraid, (10) creative and brave, (11) think outside the box (12) can apply theories in application development, (13) see opportunity in systems, (14) initiative, (15) separate work and being available, (16) self-sufficient.

In a study carried out in New Zealand and Cyprus (Licorish et al., 2022), the experience of 115 students during participation in course projects was analyzed.

Among their findings, they indicated that students with previous experiences in development teams had more satisfaction with collaborative performance than with technical contributions. Students identified technical skills (coding, tools, framework), teamwork, project management, and communication as the most important skills learned during the development of course projects. The challenges identified during each project were lack of technical skills, poor time management, poor teamwork, poor communication and lack of motivation. In an analysis of the technical and soft skills required in software development (Pando Soto & Rodríguez Rafael, 2020), where 100 job advertisements on Web platforms related to software engineering were examined and validating the indicated skills with 49 IT-related companies in Latin American countries and 15 certified professionals in PSP, it was discovered that PSP provides most of the skills for software development.

Soft skills were classified into five aspects of development: Dealing with the user, Dealing with the team, Frequent communication, Extrovert were identified in the requirements stage; in the Design stage, Analysis and problem solving, Separate problems into components, Innovative; In the Construction stage, Open-minded, Thinking, Receptive; in the Testing stage, Responsive and good judgment, Know unit tests up to integration and finally, as an Integral stage, configuration management, Focused on quality, software management, Know tools and methods, Know processes, Measure and organize their times and forecast duration of tasks. Particularly the Extroverted skill is considered important by some companies. In the literary exploration carried out by (Borges & Gratão de Souza, 2024) of 56 articles referring to the desirable soft skills in software engineers. Based on this exploration, the FraSSD was proposed, a reference framework for the development of soft skills, with the objective of contributing to the improvement of the teaching-learning process.

The key skills identified were Motivation, Attention, Working under pressure, persistence, technical literacy, awareness of the environment, debating, providing feedback, stress management and metacognition.

The framework consists of four phases: Contextualization (Co) focused on gathering, adjusting the scope of the project and foreseeing the necessary resources; Project (Pr) aimed at planning the project, assigning tasks, deadlines and support tools, communicating the skills to be developed and providing feedback on performance; Metrics (Me) defines the evaluation criteria and the corresponding weighting, forms a scoreboard to promote competitiveness and feedback; Finally, the Evaluation (Ev) consists of assigning a summative evaluation based on those established in the previous phase, also providing a growth outlook for students.

Methodology

In this article, a bibliographic exploration was carried out regarding the key skills of software engineers. Subsequently, the official documentation of the ISO/IEC 29110 standard was examined to identify the roles of the work team and the objectives of the basic profile processes.

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The ISO/IEC 29110 standard (ISO/IEC, 2011) identifies five related roles in the work team (WT): Analyst (AN), Designer (DES), Programmer (PR) and Technical leader (TL). Also, the role of Project Manager (PM) in charge of several work teams. There is also the role of Client (CUS), which can be played by a representative of the Client, see table 1.

Box 1

Table 1

Roles of the ISO/IEC 29110 standard

Role	Knowledge areas
Analyst	Software requirements. Design of user interfaces and ergonomic criteria. Review techniques. Editing techniques. Software development and maintenance.
Customer	Customer processes and ability to explain Customer requirements. Authority to approve requirements and their changes. Application domain.
Designer	Software component and architecture design. Review techniques. Integration tests. Knowledge of editing techniques. Development and maintenance of Software.
Programmer	Programming, integration and unit testing. Review techniques. Editing techniques. Software development and maintenance.
Project Manager	Leadership decision making Personnel planning and management Delegation and supervision Finance and Software development.
Technical Leader	Mastery of the Software process.

Source: based on the NTP role table - ISO/IEC RT 29110-5-1-2

Particularly, it is desirable that students new to the SDC have at least the key skills to join a work team. It is also the responsibility of the SDC to provide training and training to enhance these skills.

Based on the recommended areas of the ISO/IEC 29110 standard and the bibliographic exploration, we propose the essential competencies of professionals in the field of software development mentioned below:

Soft skills

- Critical thinking: It is a cognitive skill related to reasoning, problem solving and decision making. (Rivadeneira Barreiro et al., 2019)
- Problem analysis and resolution: Is the ability to identify a problem, take logical steps to find a desired solution, and monitor and evaluate the implementation of that solution. (UNICEF, n.d.)
- Integrity: It is following the rules and doing the right thing, acting with honesty and transparency. It is essential in the work environment because it promotes trust, ethics and responsibility. (ESS,2024)
- Humbleness: Ability to know one's own limitations and weaknesses and act accordingly, recognize the validity of other points of view.
- Proactivity: Having self-initiative, active intervention, anticipating events. (PMI,2013)
- Self-management: The ability to efficiently manage various tasks and meet the schedule without wasting resources; the ability to perform tasks with minimal supervision. (PMI,2013)
- Assertive communication: The ability to convey information that is well received and understood. includes the ability to deal with other people through social interactions and communication under favorable and unfavorable conditions. (PMI,2013)
- Self-learning: The ability to learn new concepts, methodologies and technologies on your own. (PMI,2013)
- Empathy: ability to identify with someone and share your feelings. (PMI,2013)
- Responsibility: Ability for a person to recognize and perform assigned tasks and work expected to complete the activities of this person. (PMI,2013)
- Teamwork: ability to work effectively in team environments and contribute towards the desired objective. (PMI,2013)
- Leadership: Ability to direct, guide and motivate others; leads the group to achieve objectives. It is especially important to communicate the vision and inspire the project team to achieve high performance. (PMI,2013)

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Technical skills

- Adherence to processes: Ability to adopt software engineering processes, which consist of a set of activities, actions and tasks to be carried out in software projects with the purpose of obtaining quality software and timely delivery. (Pressman, 2010)
- Use of collaborative and project management tools: Ability to use applications designed to improve teamwork and communication virtually, allowing a work group to collaborate on a project in real time or communicate without having to be online. the same physical place. (RICOH,2021)
- Project management: Knowledge and techniques related to coordinating processes, tools, team members and skills so that the project meets the proposed objectives. (Atlassian, n.d.)
- Risk management: Ability to carry out risk management planning, as well as the identification, analysis, response planning and control of a project's risks. (Pressman, 2010)
- Quality focus: Ability to use and manage QA quality assurance activities (SQA).
- Programming Knowledge: It is essential to have basic knowledge of at least one programming language such as C#, Java, Python, etc.
- Knowledge of methodologies: It is essential to have notions about software development methodologies, agile or formal, know Scrum, PSP, TSP, etc.

In general, it is desirable that new members who join a team under the ISO/IEC 29110 standard meet and develop some general skills, see table 2.

Box 2

Table 2

Common role skills

Soft skills	Technical skills
- Teamwork - Assertive communication - Proactivity - Critical thinking	- Management of collaborative and project management tools - Adherence to processes

Source: own elaboration

By individually analyzing each role, desirable technical and soft skills were identified to fulfill responsibilities and activities, see table 3.

Box 3

Table 3

Role skills

Role	Soft skills	Technical skills
AN	- Integrity - Humbleness	
DES	- Analysis and resolution of problems - Self-learning	- Quality focus - Programming Knowledge
PR	- Analysis and resolution of problems - Integrity - Self-management - Self-learning	- Quality focus - Programming Knowledge
PM	- Integrity - Self-management - Empathy - Responsibility - Leadership - Humbleness	- Project management - Risk management - Quality focus - Knowledge of methodologies
TL	- Analysis and resolution of problems - Empathy - Self-management - Responsibility - Leadership - Humbleness	- Risk management - Project management - Knowledge of methodologies

The essential skills set out above are focused on new members being able to carry out their activities in a work team, promoting collaboration, motivation and maintaining the development of high-quality products.

Conclusions

The adoption of the ISO/IEC 29110 standard in Software Development Centers (SDCs) frames a dynamic of professional training through projects framed in a quality approach, allowing students to participate in projects in real conditions and develop skills that allow them to be competitive and generate quality products.

This article highlights the desirable skills for new students who will join work teams under the ISO/IEC 29110 standard, among the most basic are: Teamwork, Assertive communication, Proactivity, Critical thinking, Use of collaborative tools and project management and adherence to processes.

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It is important for SDCs to establish mechanisms to diagnose and train new members, with the aim that their incorporation into the new team is more enriching.

Discussion

Various articles point out the importance of soft skills that has been accentuated in recent years, with different proposals for their definition, diagnosis and development.

It is frequently observed that, beyond the technical aspects, the sense of collaborative achievement in work teams is key to enhancing the performance of its members.

On the other hand, SDCs allow universities to train more prepared and competitive professionals, but it is worth emphasizing that training must be structured to develop key skills in new engineers; it is recommended to use frameworks, such as FraSSD (Borges & Gratão de Souza, 2024), that facilitate the acquisition and development of skills under an organized and measurable approach.

Finally, it is important to maintain training programs with feedback mechanisms and adaptability to new trends.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Arredondo-Salcedo, Daniel: Contributed to the project idea, data analysis, reference framework, and literature exploration.

Salas-Guzmán, Manuel Ignacio: Contributed to the project idea, editing, methodology and interpretation of results.

García-Molina, Yolanda Meredith: Contributed to the project idea, data analysis, references reviews and literature exploration.

Availability of data and materials

Data will be made available on request.

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Abbreviations

List abbreviations in alphabetical order.

AN	Analyst
CL	Customer
DES	Designer
FraSSD	Framework for Soft Skills Development
PM	Project Manager
TL	Technical Leader
PR	Programmer
SDC	Software Development Centers
WT	Work Team

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References

Antecedents

Colomo-Palacios, R., Casado-Lumbreras, C., Soto-Acosta, P., García-Peñalvo, F. J., & Tovar-Caro, E. (2013). Competence gaps in software personnel: A multi-organizational study. *Computers in Human Behavior*, *29*(2), 456–461.

Basics

Atlassian. (n.d.). *La guía completa para la gestión de proyectos*. Retrieved June 14, 2024,
Castillo-Salinas, L., Sanchez-Gordon, S., Villarroel-Ramos, J., & Sánchez-Gordón, M. (2020). Evaluation of the implementation of a subset of ISO/IEC 29110 Software Implementation process in four teams of undergraduate students of Ecuador. An empirical software engineering experiment.

ESS, Soluciones de formación globales. (2024). *Desarrolla Habilidades: Integridad en el trabajo*.

ISO/IEC. (2011). *TECHNICAL REPORT ISO/IEC 29110-5-1-2.* Retrieved June 14, 2024,
Muñoz, M., Mejia, J., Peña, A., Lara, G., & Laporte, C. Y. (2019). Transitioning international software engineering standards to academia: Analyzing the results of the adoption of ISO/IEC 29110 in four Mexican universities.

PMI, P. M. I. (2013). GUÍA DE LOS FUNDAMENTOS PARA LA DIRECCIÓN DE PROYECTOS (GUÍA DEL PMBOK). In P. Management & Institute (Eds.), *Guia de los Fundamentos para la direccion de Proyectos* (Quinta).

Pressman, R. S. (2010). *INGENIERÍA DEL SOFTWARE. UN ENFOQUE PRÁCTICO* (7ma.). Mc GRAW-HILL INTERAMERICANA EDITORES.
RICOH, E. S. D. (2021). *Principales herramientas colaborativas para la comunicación con tu equipo*.

Rivadeneira Barreiro, M. P., Hernández Velásquez, B. I., Loor Lara, D. L., & Palma Villavicencio, M. M. (2019). El fortalecimiento del pensamiento crítico en la educación superior. *Revista Boletín Redipe*, *8*(11), 44–49.

UNICEF. (n.d.). *Misión #4 - Resolución de problemas*.

Supports

Assyne, N., Ghanbari, H., & Pulkkinen, M. (2022). The essential competencies of software professionals: A unified competence framework. *Information and Software Technology*, *151*, 107020.

Borges, G. G., & Gratão de Souza, R. C. (2024). Skills development for software engineers: Systematic literature review. *Information and Software Technology*, *168*, 107395.

Licorish, S. A., Galster, M., Kapitsaki, G. M., & Tahir, A. (2022). Understanding students' software development projects: Effort, performance, satisfaction, skills and their relation to the adequacy of outcomes developed. *Journal of Systems and Software*, *186*, 111156.

Pando Soto, B. C., & Rodríguez Rafael, G. (2020). Habilidades de Personal Software Process (PSP) para la industria del software en Latinoamérica. *Industrial Data*, *23*(1), 229–

Differences

Discussions

Borges, G. G., & Gratão de Souza, R. C. (2024). Skills development for software engineers: Systematic literature review. Information and Software Technology, 168, 107395.

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Article

Measurement of refractive index in liquid mixtures using Interferometry

Medición del índice de refracción en mezclas líquidas mediante interferometría

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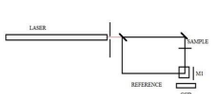
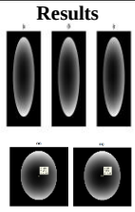
Abstract

The main parameters that govern the changes in the speed of light when interacting with matter are polarizability and electronic density. The first relates to the ability of a group of atoms to deform under the action of an electromagnetic field, while the second is directly linked to the mass of the substance. If a beam of reference light and another that is incident in the medium whit molecular variation are superimposed, they will be producing a pattern of interference fringes by the phase shift. In this paper we report the results obtained in the measurement of the change in refractive index of liquids substances using patterns of interference fringes. To check the applicability of the technique, two mixtures of different liquid substances were used in the experiment. Water and gasoline were used as solvents and ethanol and gasoline additive were used as solutes, each at different percentages. The results suggest that it is feasible to analyze the variation of the concentration, density and change of refractive index of a substance, through the direct relationship between the molecular changes of the substance analyzed and the phase difference.

Measurement of refractive index in liquid mixtures using Interferometry

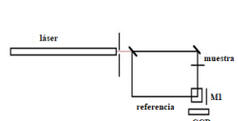
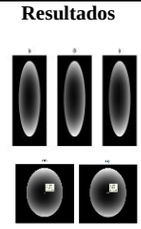
Objective	Methods	Results
Measurement refractive index using interference. Analyze the variation of the concentration	Use interferometric techniques 	

Liquid substances, refractive index, interferometry.

Resumen

Los principales parámetros que gobiernan los cambios en la velocidad de la luz al interactuar con la materia son la polarizabilidad y la densidad electrónica. La primera se relaciona con la capacidad de un grupo de átomos de deformarse bajo la acción de un campo electromagnético, mientras que la segunda está directamente vinculada con la masa de la sustancia. Si se superponen un haz de luz de referencia y otro que incide en el medio con variación molecular, se estará produciendo un patrón de franjas de interferencia por el desplazamiento de fase. En este trabajo reportamos los resultados obtenidos en la medición del cambio de índice de refracción en sustancias líquidas utilizando patrones de franjas de interferencia. Para comprobar la aplicabilidad de la técnica se utilizaron en el experimento dos mezclas de distintas sustancias liquidas, como solvente se utilizaron el agua y gasolina y como soluto etanol y aditivo de gasolina, a distintos porcentajes cada uno. Los resultados sugieren que es factible analizar la variación de la concentración, densidad y cambio de índice de refracción de una sustancia, a través de la relación directa entre los cambios moleculares de dicha sustancia y la diferencia de fase.

Medición del índice de refracción en mezclas líquidas mediante interferometría

Objetivo	Métodos	Resultados
Medición de índices de refracción usando interferometría. Análisis de la concentración de una muestra	Uso de técnicas interferométricas 	

Sustancias líquidas, índice de refracción, interferometría.

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Introduction

Background

Refractive index changes and chemical analysis are of great interest in the study of the parameters that determine the composition of different substances, and can be applied in different areas of engineering, medicine and biology [1]. The analysis of changes in substances provides an important basis in the study of the characteristics that compose them, such is the case of the study of oils, water and alcohols; being a predominant analysis when an in situ measurement is performed [2,3].

At present, there are numerous methods and studies carried out to determine the refractive index of a substance, which base their principle of operation on the measurement of the critical angle or refractive angle of the material medium analysed. Deosarkar *et.al* in a study conducted on mixtures of ethanol and water with different concentrations of potassium salts showed a linear behaviour between the density and the refractive index of the mixtures analysed [3], S. Ubarhande, analysing binary liquid mixtures with different percentages of solute, indicated that the molar refractivity depends on the refractive index, pressure and temperature, and also determined that as the percentage of solute increases, the molar refractivity and the polarisability constant also increase, attributing this change to an intermolar force caused by the formation of a dipole [5].

Another reported technique is refractometry, which allows measurement of changes in the properties of light as it interacts with a substance, and is non-invasive as it does not come into contact with the sample. However, it has shortcomings in the measurement as it depends directly on the experience of the operator, making it not very accurate, it is not full-field and requires several refractometers [6-8]. Currently, other techniques capable of providing the characteristics of the analysed medium without requiring an elaborate system have been implemented, such is the case of digital holography, this technique is based on the acquisition, processing and mathematical reconstruction of images, however, the disadvantage of this technique is the measurement range due to the measurement frequencies, requiring the use of other processing techniques [7-12].

Another optical technique presented is interferometry, which bases its principle of operation on the superposition of two coherent light waves that originate an interference fringe pattern, which provides information about the analysed surface, when this surface is subjected to a perturbation, such changes can be correlated with the deformation [13,14].

With this, it can be mentioned that the use of optical metrology has allowed in recent years, the development of various methods for studies focused on changes in substances, especially in structural analysis; in the case of the study of liquid materials, optical techniques provide a measurement in real time and without contact with the material. Such is the case of the fibre optic sensor, which is based on monitoring the change of the optical signals propagating along the optical fibre [15]. Selvas Aguilar *et al.* propose the use of a fibre optic sensor for the measurement of refractive index in liquids, the sensor relates the trajectories followed by the reference light beam and another in the sample, obtaining a resolution of $^{10\text{-}3}$ [16].

Other studies of liquid mixtures, in this case using gasoline, focus on the vapour pressure properties to determine the variations when anhydrous ethanol is added at different volumetric values, thus measuring the quality standards [17], The physicochemical characteristics of commercial blends of Mexican gasoline (Magna and Premium) and diesel with 10% and 15% anhydrous ethanol have also been studied, estimating theoretical$_{CO2}$ emissions for each of the blends [18].

Despite these advances, the study of structural changes with accessible techniques that are not affected by environmental changes is the objective of this work.

Mathematical modelling

The density dependence of a substance is given by the Lorentz and Lorenz equation, where *r* represents the specific refraction of the substance, *n* describes the refractive index and *d represents* the density of the medium.

$$r = \frac{n^2-1}{d(n^2+2)} \quad (1)$$

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In general, the refractive index is made up of its temperature T, its concentration c and the wavelength λ with which the sample is incident on the sample, the change in one of these three parameters shows changes in the refractive index, causing variations in the optical path, represented as [10-12]:

$$\Delta\varphi = \frac{\Delta n}{\Delta T}\Delta T + \frac{\Delta n}{\Delta \lambda}\Delta\lambda + \frac{\Delta n}{\Delta c}\Delta c \quad (2)$$

When using a monochromatic light source $\Delta\lambda = 0$, and considering a constant temperature, the changes in the refractive index will depend only on the concentration of the sample.

$$\Delta\varphi = \frac{\Delta n}{\Delta c}\Delta c \quad (3)$$

The resulting phase change contribution will be represented by the densities ρ of each of the binary substances by means of:

$$\rho = \frac{m}{v} = masa/volumen \quad (4)$$

Since the refractive index is represented by the speed of light relative to the speed of the medium and corresponds to a constitutive property of matter, it suggests that changing the density of the substance will affect the optical path of the beam through the medium.

A monochromatic optical field can be described as:

$$\vec{E}(r,t) = \vec{E}_0(r,t)e^{i(wt+\emptyset(r,t))} \quad (5)$$

Where, $\vec{E}_0(r,t)$ represents the complex amplitude of the field, w the angular frequency and, $\emptyset(r,t)$ is the phase, with a phase change, equation 3 can be re-stated as:

$$\emptyset(r,t) = \frac{2\pi}{\lambda}L(r,t) \quad (6)$$

In this case, λ is the wavelength of the incident light, which results in the measurement of the refractive index as:

$$\emptyset(r,t) = \frac{2\pi}{\lambda}\left(\frac{\Delta n}{\Delta c}\Delta c\right) \quad (7)$$

As shown in equation 3, changes in sample concentration will contribute to a change in refractive index, which is studied as a change in optical path, using the principles of wave superposition and the theoretical analysis of the wave equation, equation 8.

When two of the wavefronts fulfil this principle by showing similar spatial and temporal characteristics, as indicated in equations 9 and 10, an amplitude of two superimposed signals results, equation 11.

$$\nabla E(x,y,z,t) = \frac{1}{c^2}\frac{\partial E(x,y,z,t)}{\partial t} \quad (8)$$

$$E_1 = E_1\cos(wt+\phi_1) \quad (9)$$

$$E_2 = E_2\cos(wt+\phi_2) \quad (10)$$

$$E_T = E_1^2 + E_2^2 + 2E_1E_2\cos(\delta) \quad (11)$$

$$\delta = (\phi_1 - \phi_2) \quad (12)$$

Where E_1 y E_2, represent the amplitudes of fields and E_T is the result of the phenomenon known as interference, which together form the fringe pattern. If it is considered that the phase difference is a function of the difference in the optical path travelled by the two waves, it follows that [19]:

$$\delta = (Kx_1 + \varepsilon_1) - (Kx_2 + \varepsilon_2) \quad (13)$$

If the two waves are in phase, with $\varepsilon_1 = \varepsilon_2$, and the electromagnetic wave is studied when it undergoes a phase variation equal to 2π, the phase variation δ when the wave travels a distance d in a medium of refractive index n_1, is given by:

$$\delta = \frac{2\pi}{\lambda}nd \quad (14)$$

If one considers the sensitivity vector of the system, as shown in:

$$d(x,y,z) = \frac{\lambda}{2\pi}\frac{\Delta\varphi(x,y,z)}{\vec{a}(x,y,z)-\vec{b}(x,y,z)} \quad (15)$$

Where $\vec{a}(x,y,z)$ and $\vec{b}(x,y,z)$ correspond to the distance between the observation point to the surface under analysis and the illumination point to the object, respectively.

In this work an alternative for the measurement of the refractive index of liquid substances is proposed, determining their molecular changes through an interferometric fibre optic system, the phase of the different values of density of the substance was analysed and the characteristic phase map was obtained, the results suggest that the behaviour of the refractive index and the phase is linearly descending, as the refractive index increases the phase decreases.

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The results suggest that the behaviour of the refractive index and phase is linearly decreasing, as the refractive index increases the phase decreases, which is found in the phase map, through this system it can also be demonstrated that the displacements in the propagation of light caused by the molecular changes of the substance are of the order of microns (μ), that is, the density in the medium causes changes in the optical path of an electromagnetic wave and the refractive index in the medium, the propagation velocity of the electromagnetic wave will be affected, producing a decrease in this velocity.

Methodology

Measurement process

To obtain the interference fringes, a Mach Zehnder interferometer, a fibre optic multiplexer (2x2 Thorlabs TW630R5F2), a coherent light source at 632.8nm, a 20x microscope objective and a SM600 coupler were used.

One end of the multiplexer was pointed towards the diffusion cell; the other end was positioned parallel to it, both pointing towards a beam splitter. Images were obtained using an XC-77 CCD camera with a pixel size of 11×13μm, and a computer to process the data, figure 1.

As first experiments, water was used as the reference liquid and ethanol as the immersion liquid; the percentages of ethanol were added in the reference sample, varying its concentration between 5, 10, 15, 20 and 25 (v/v%).

To continue with the verification of the technique in the measurement of characteristics in liquid substances, 87 octane gasoline was used, and 5 v/v% was added, the optical phase was also calculated.

Box 1

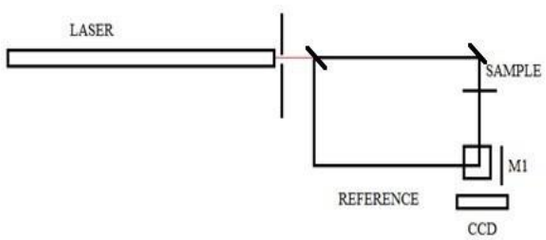

Figure 1

Interferometric system used to obtain fringe patterns with different solute concentrations

Results

Experimental results

Since the density and concentration of the substance is related to the mass and volume contributions, the calculation of the refraction in each binary mixture was carried out. Comparing the density of the immersion liquid with an approximate value of 0.8054 g/ml, with the liquid of higher density, around 0.9957 g/ml; ethanol and water, respectively [4]. For the first case the highest refraction was presented, as the density of the liquid approaches the maximum, the refraction of the incident light beam is affected decreasing until reaching the value proportional to the density of ethanol, the results were obtained through equation 4 [4,11,14].

Box 2

Table 1

Densities, refractive indices and differences between indices for different concentrations of ethanol [4,11,14]

Liquid	Density $g \cdot cm^{-3}$	Refractive Index	Specific Refraction
Water	0.9957	1.333	0.2068
Ethanol 5%	0.9858	1.3345	0.2095
Ethanol 10%	0.9770	1.3358	0.2121
Ethanol 15%	0.9689	1.3371	0.2147
Ethanol 20%	0.9616	1.3382	0.2169
Ethanol 25%	0.9549	1.3392	0.2190
Ethanol 40%	0.9378	1.3418	0.2246
Ethanol 60%	0.9203	1.3445	0.2305
Ethanol	0.8054	1.362	0.2754

For the analysis of the changes with water and ethanol, the results are shown in figure 2, while the results for experimental stage 2 with gasoline and additive are shown in figure 3.

Box 3

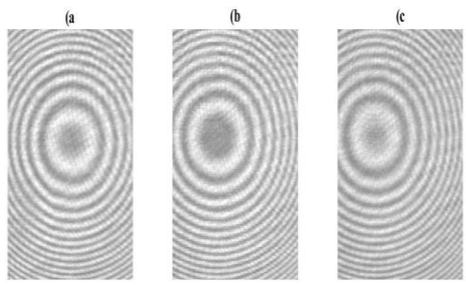

Figure 2

Interference fringe pattern obtained between the reference (a), water (b) and ethanol (c)

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Box 4

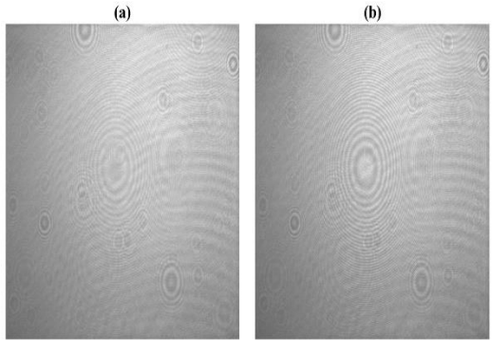

Figure 3

Interference fringe pattern obtained between reference (a), 87 octane petrol (b) petrol with 5 v/v% additive

Circular fringe patterns are presented, in the case of petrol interferograms, so the analysis of the patterns was performed for circular fringe demodulation, in both cases.

Box 5

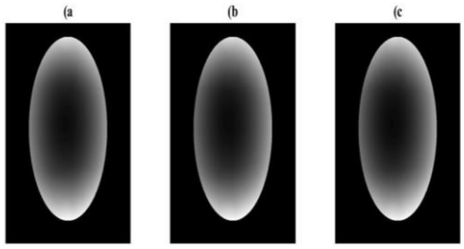

Figure 4

Phase map of each interferogram: (a) reference (b) water and (c) ethanol

Box 6

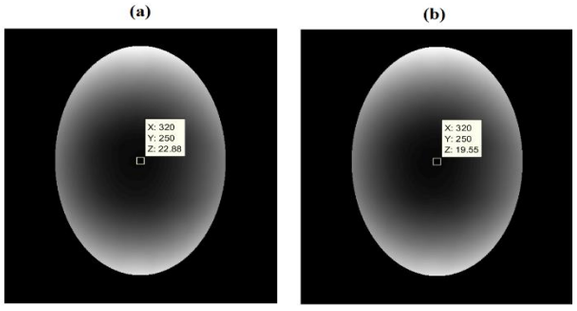

Figure 5

Phase map of each interferogram: (a) 87 octane gasoline (b) gasoline with additive

Conclusion

In this work we show the results obtained in the measurement of the refractive index of binary liquid substances, using a Mach Zehneder fibre optic interferometer.

The results show a rising behaviour between the density and the characteristic phase of each interferogram and although they keep their circular shape, they show a phase change. In the case of the phase map analysis of the petrol samples, the phase map also shows a decrease in intensity. The results shown suggest a shift in the x-axis, causing a change in the position of the interference fringes.

The results shown suggest that the refractive index of a substance is directly linked to its density and that these changes in the fringe pattern present characteristics of the medium, affected by the different concentrations of the substance analysed, which makes the idea of carrying out purity studies on substances using interferometric techniques feasible. It was possible to obtain a phase and correlate it with changes in the refractive index of binary mixtures, which makes it feasible to use fibre optic interferometers as optical sensors for the measurement and prediction of refractive indices.

Also, with the results obtained, it can be verified that optical techniques provide good results in the analysis of the characteristics of liquid substances with volatility characteristics such as ethanol and gasoline.

Conflict of interest

The authors declare that they have no conflict of interest.

Authors' contribution

López-Álvarez, Yadira Fabiola: Experimentation and demodulation of interference fringes.

Peña-Lecona, Fransisco Gerardo: Experimental design, previous studies.

Jara-Ruiz, Ricardo: Modelling of PSO techniques for fringe demodulation.

Rodríguez-Franco, Martin Eduardo: Research and review.

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References

Background

[1] Schreiber, B., Wacinski, C., & Chiarello, R. (2013). Index of refraction as a quality control metric for liquids in pharmaceutical manufacturing. Pharm Eng, 33(2), 1-7

[2] Yang, M. K., Kaplan, S. G., French, R. H., & Burnett, J. H. (2009). Index of refraction of high-index lithographic immersion fluids and its variability. *Journal of Micro/Nanolithography, MEMS and MOEMS*, *8*(2), 023005-023005

[3] Lomer, M., Zubia, J., Conde, O. M., Mirapeix, J. M., Cubillas, A. M., & Lopez-Higuera, J. M. (June 2004), In situ refraction index of liquid measurement using polymer optical fibers. In Second European Workshop on Optical Fibre Sensors, International Society for Optics and Photonics, 325-328

Fundamentals

[4] Deosarkar, S. D., Pandhare, V. V., & Kattekar, P. S. (2013). Densities and Refractive Indices of Potassium Salt Solutions in Binary {Ethanol+ Water} Mixture of Different Compositions. *Journal of Engineering*, *2013*(1), 368576

[5] Ubarhande, S. S., Burghate, A. S., Berad, B. N., & Turak, J. D. (2011). Studies on refractive index of 1, 3-diaryl carbamides in different percentage of binary liquid mixture. *Rasayan Journal of Chemistry*, *4*(3), 585-587

[6] Burchard, U., & Medenbach, O. (2009). The refractometer. *The Mineralogical Record*, *40*(2), 135

[7] Olsen, E. D. *Métodos Ópticos de Análisis*; Reverté: Barcelona, 1990,

[8] Mujica, F. J. C. (2013). Método teórico para la predicción del índice de refracción en refractometría. *Boletín científico técnico INIMET*, (2), 1-18.

Support

[9] Anand, A., Pedrini, G., Osten, W., & Almoro, P. (2007). Wavefront sensing with random amplitude mask and phase retrieval. Optics letters, 32(11), 1584–1586.

[10] Solimini, D. (1966). *Loss Measurement of Organic Materials at 6328 Å*. *Journal of Applied Physics, 37(8), 3314–3315.*

[11] Jon P. Longtin Ching-Hua Fan. (1998). Precision Laser-Based Concentration and Refractive Index Measurement of Liquids. Microscale Thermophysical Engineering, 2(4), 261–272.

[12] C.H. Fan, J.P. Longtin, Laser –Based measurement of liquids temperature or concentration at a solid-liquids interface (2000), Exp. Therm. and Fluid Sci., 23, 1-9

Differences

[13] R. B. Santiago Neto, J. P. Rodrigues Furtado de Mendonca, B. Lesche (June 2004), Determination of Absolute Values of Refractive Index of Liquids Using an Interferometric Method, Rev. de Fís. Ap. e Inst., 17(2), 74-79,

[14] F. Velazco Aparicio (2018), Analizadores en proceso en línea, introducción a sus técnicas analíticas, ISA, 197-200

Discussion

[15] Shizhuo Yin, Francis T.S. Yu (2002), Fiber Optic Sensor, Dekker, New York, Chap. 5 p.183

[16] R. Selvas-Aguilar, A. Castillo-Guzman, L. CortezGonzalez, D. Toral-Acosta, A. Martinez-Rios, G. Anzueto-Sanchez, V. M. Duran-Ramirez, and S. Arroyo-Rivera (2016), Noncontact Optical Fiber Sensor for Measuring the Refractive Index of Liquids, J. of Sens.

ISSN: 2523-2460.
RENIECYT-CONAHCYT: 1702902

López-Álvarez, Yadira Fabiola, Peña-Lecona, Francisco Gerardo, Jara-Ruiz, Ricardo and Rodríguez-Franco, Martín Eduardo. [2024]. Measurement of refractive index in liquid mixtures using Interferometry. Journal of Technical Education. 8[20]1-7: e5820107.
https://doi.org/10.35429/JTE.2024.8.20.5.7

[17] Torres, J., Molina, D., Pinto, C., & Rueda, F. (2002). Study of the blending of petrol with 10% anhydrous ethanol. Evaluation of physicochemical properties. *CT&F - Ciencia, Tecnología Y Futuro*, *2*(3), 71–8

[18] Castillo Hernández, P., Mendoza Domínguez, A., & Caballero Mata, P.(2012). Análisis de las propiedades fisicoquímicas de gasolina y diesel mexicanos reformulados con Etanol. Ingeniería, investigación y tecnología, 13(3), 293-306

[19] José M. Virgós Rovira, José Rodríguez García (1998), Fundamentos de óptica ondulatoria, 50, ISBN 10 8483171171

ISSN: 2523-2460.
RENIECYT-CONAHCYT: 1702902

López-Álvarez, Yadira Fabiola, Peña-Lecona, Francisco Gerardo, Jara-Ruiz, Ricardo and Rodríguez-Franco, Martín Eduardo. [2024]. Measurement of refractive index in liquid mixtures using Interferometry. Journal of Technical Education. 8[20]1-7: e5820107.
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Article

Quadrotor Helicopter with Open Architecture

Helicóptero Cuadrirrotor en Arquitectura Abierta

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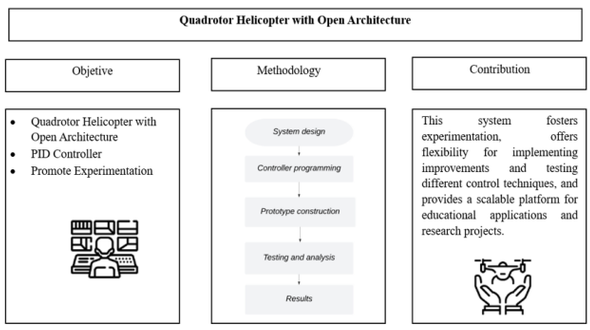
Abstract

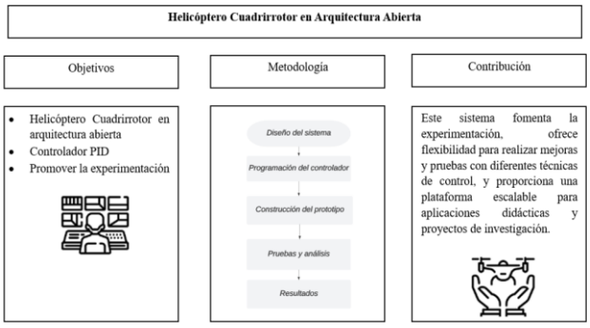
The article focuses on the design, construction, and testing of a quadrotor helicopter with open architecture, aiming to explore control techniques and promote experimentation in unmanned aerial vehicles. Tools such as MATLAB and Simulink were used to program a classic PID controller, evaluating aspects like error margin and stabilization under perturbations. Additionally, references with the commercial DJI NAZA MLITE controller were implemented to obtain comparative data. The prototype stands out for its flexibility, allowing component upgrades and preventing obsolescence. Finally, the application of advanced techniques, such as fuzzy logic and genetic algorithms, is suggested for future research to enhance its functionality and potential.



Quadrotor, Open Architecture, Didactic System

Resumen

El artículo aborda el diseño, construcción y pruebas de un helicóptero cuadrirrotor en arquitectura abierta, con el objetivo de explorar técnicas de control y fomentar la experimentación en vehículos aéreos no tripulados. Se utilizaron herramientas como MATLAB y Simulink para programar un controlador PID clásico, evaluando aspectos como el margen de error y la estabilización ante perturbaciones. Además, se implementaron referencias con el controlador comercial DJI NAZA MLITE para la obtención de datos comparativos. El prototipo se caracteriza por su flexibilidad, permitiendo la actualización de componentes y evitando la obsolescencia. Finalmente, se sugiere la aplicación de técnicas avanzadas, como lógica difusa y algoritmos genéticos, en futuras investigaciones para ampliar su funcionalidad y potencial.



Cuadrirrotor, Arquitectura abierta, Sistema didáctico

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Introduction

Quadrotor helicopters have played a crucial role in the evolution of vertical take-off vehicles. Although the first models had limited performance, they became pioneers in the development of this technology.

In 1922, George de Bothezat, an American engineer, succeeded in flying the first quadrotor helicopter, although it did not exceed 5 metres in height (figure 1). (Heartland Science, 2015).

Box 1

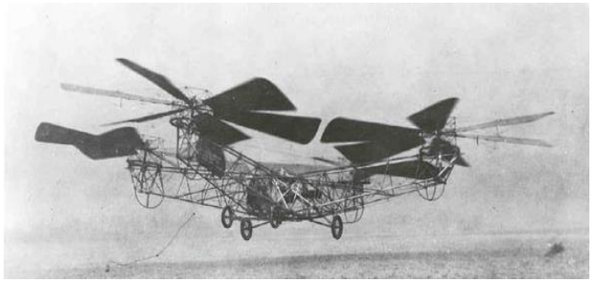

Figure 1
Cuadrirrotor de Bothezat
Source: [Hearland Science, 2015]

At the same time, in Europe, the Frenchman Étienne Œhmichen built his own quadrotor model in 1922. In June 1923, it achieved a stationary flight of five minutes, and in 1924 it reached an altitude of 10 metres in a seven-minute flight (Guerrero, 2014).

In recent years, unmanned vehicles based on four-propeller configurations, known as drones or multi-rotors, have been developed. For example, Hernandez (2014) presents a design of an open architecture quadrotor vehicle with an operating range of 90 metres indoors and up to 1,500 metres outdoors, built with a budget of less than $500 USD. This device was designed using open source hardware and software platforms, allowing for scalability, future enhancements, cost reduction and feature expansion. This system is able to perform take-offs, landings and changes in its flight path, using an inertial measurement unit and a basic stabilisation algorithm. Also, through specifically developed applications, the pilot can teleoperate the system from devices such as computers, laptops or tablets.

The work of Hernández (2014) highlights the importance of low-cost drones by eliminating the reliance on foreign technologies or reverse engineering of similar commercial products. This approach provides the Mexican scientific community with the necessary basis to replicate, improve and adapt these systems to different needs, contributing to technological progress in the country.

On the other hand, Tavares (2014) describes the implementation of a Proportional Derivative (PD) controller for the lift and stabilisation of a quadrotor helicopter. His contribution lies in the design, construction and documentation of an open architecture prototype, suitable for reproduction, modification or improvement for teaching and research purposes. The experiments carried out demonstrated the efficiency of the controller, which showed excellent response to external disturbances, such as slight shocks to the helicopter structure, managing to follow the desired reference with a minimum regulation error.

Additionally, educational systems such as the Quanser (n.d.) 2 and 3 Degrees of Freedom (GDL) helicopters are valuable tools for teaching flight dynamics and advanced control concepts.

The 2 GDL model, figure 2, emulates a helicopter with main and tail rotor, providing interesting modelling and control challenges due to the inherent torque effect.

Box 2

Figure 2
Helicopter 2 GDL manufactured by Quanser
Source: [Quanser, s.f.]

The 3 GDL system, figure 3, includes two parallel-mounted propellers and an adjustable counterweight, which allows control of the helicopter's displacement and elevation.

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Box 3

Figure 3
3 GDL Helicopter manufactured by Quanser
Source: [Quanser, s.f.]

The *Hover* system, figure 4, with three degrees of freedom, uses a round frame with four propellers driven by DC motors to simulate movement about roll, pitch and yaw axes.

Box 4

Figure 4
Hover system
Source: [Quanser, s.f.]

Gomez developed a drone using Arduino Nano and claims that it provides many more advantages than pre-built drones, figure 5, (Gómez, 2020).

Box 5

Figure 5
Drone based on Arduino and open source technologies
Source: [Gómez, 2020]

In this context, the present work focuses on the design, construction and implementation of a PID controller applied to an open architecture quadrotor helicopter. Flight stabilisation is one of the major challenges in these systems, and its development represents an opportunity for research and training of future generations of control engineers. This approach aims not only to address practical problems, such as aerial stabilisation, but also to encourage experimentation with different control techniques, from classical to artificial intelligence-based, allowing for system adaptations and improvements.

The growing popularity of quadrotors, driven by their use in applications such as photography, videography and recreation, underlines the importance of addressing the associated technical challenges, such as flight stabilisation. This work contributes to the advancement of knowledge in the area, providing a scalable and accessible platform for future research and technological developments.

Open architecture prototype design and implementation

One of the main characteristics of a quadrotor is its asymmetric two-two rotation, which allows it to balance itself by applying speed to two motors on the same axis, and then perform their respective compensation calculations to allow the increase or decrease of speed, figure 6.

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Box 6

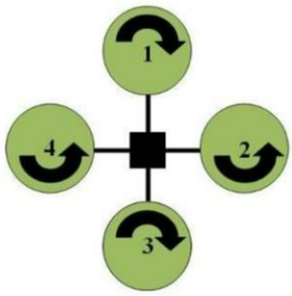

Figure 6
Quadrotor mechanics
Source*: [Rawashdeh,et. Al., 2009]*

Quadrotors present risks due to the high speeds of their motors and propellers that can cause injury. Therefore, it is recommended to test in a safe environment with a test stand that allows the device to be firmly fixed and adjustments to be made safely.

For safety, a test stand was designed to allow controlled movement on the roll and pitch axes. To ensure rigidity and vibration resistance, ¼ inch PTR parts, selected for their low cost and durability, were used. Before fabrication, the design was developed in a CAD programme, resulting in a structure with a base 30 cm long by 2.5 cm wide, side supports 20 cm high and 15 cm apart, figure 7.

Box 7

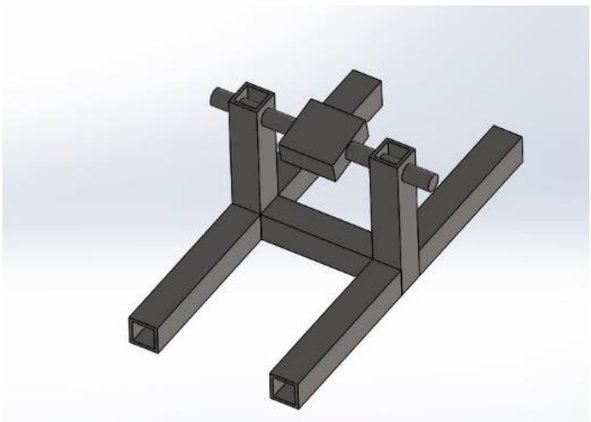

Figure 7
SolidWorks test bench
Source: [Authors]

The design of a quadrotor frame requires vibration and shock resistance, as well as lightness so as not to overload the motors. To save time and ensure compatibility, it was decided to purchase a prefabricated frame that met the necessary specifications.

A DJI F450 rigid plastic model was selected, suitable to withstand shocks and vibrations, and with compatible dimensions for mounting the engines, as shown in figure 8.

Box 8

Figure 8
Flame Wheel F450
Source: [DJI, s.f.]

Figure 9 shows the quadrotor mounted on the test stand. The design of the test stand was made in SolidWorks software, with the purpose of facilitating the reading of control signals, performing stabilisation tests and adjusting the mass balance of the quadrotor. For this assembly, the commercial controller DJI NAZA MLITE was used.

Box 9

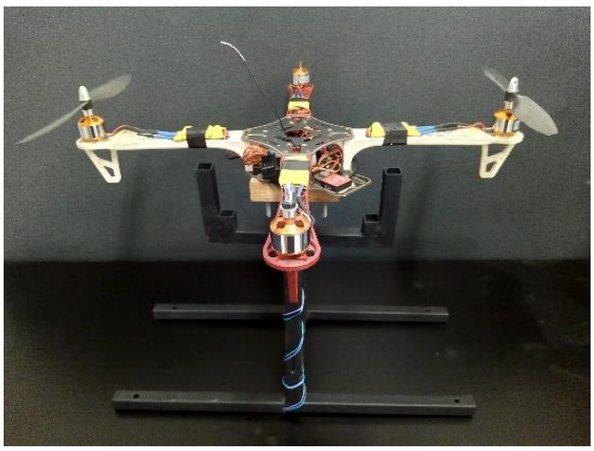

Figure 9
Quadrotor mounted on test stand
Source: [Authors]

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The communication interface between the computer and the quadrotor allows the behaviour of the controller to be monitored during the tests, figure 10. The system uses an Arduino Uno to modulate the PWM signals applied to the motors, regulating the power of each pair of motors. These signals are initially analysed by a data acquisition (DAQ) card, specifically the PCI-6221, which sends the information to an interface developed in Simulink using blocks.

The microcontroller, equipped with a PID controller, generates the necessary output signals to the motors via the ESCs, tuning their operation. The collected data is transmitted via serial communication to Matlab, where it is processed and visualised in real time using Simulink. The whole system, including the Arduino, the motors and other components, is powered by a power supply designed to guarantee the correct operation of the devices.

Box 10

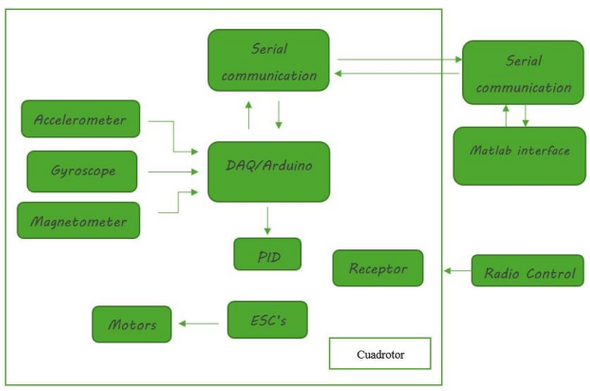

Figure 10
Quadrotor communication

Source: [Authors]

Controller design for the Quadrirrotor helicopter

The control of a quadrotor cannot be performed by an open-loop controller, as the system is inherently unstable to disturbances. Under these conditions, the control output would tend to infinity, resulting in a continuous increase in motor speed. Therefore, it is necessary to implement a feedback system using a sensor that measures the angular position. This sensor allows the control output to be dynamically adjusted to maintain system stability. Figure 11 shows the diagram of a control loop designed specifically for a quadrotor.

Box 11

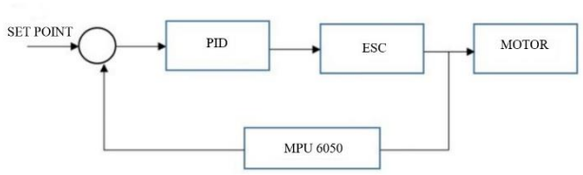

Figure 11
Quadrotor control loop

Source: [Authors]

The control loop consists of the following elements:

– PID controller
– ESC (motor variable speed drive)
– Motor
– MPU6050

This control system uses an input signal provided by the radio control, feedback from the accelerometer and gyroscope integrated in the MPU6050 module, and generates a PWM output signal. This PWM signal is sent to the variable speed drives, which adjust the speed of the motors to achieve the desired speed.

Figure 12 shows the program developed in Matlab software to implement the Quadrirrotor control. It presents an overview of all the programming blocks used in the development of the controller.

Box 12

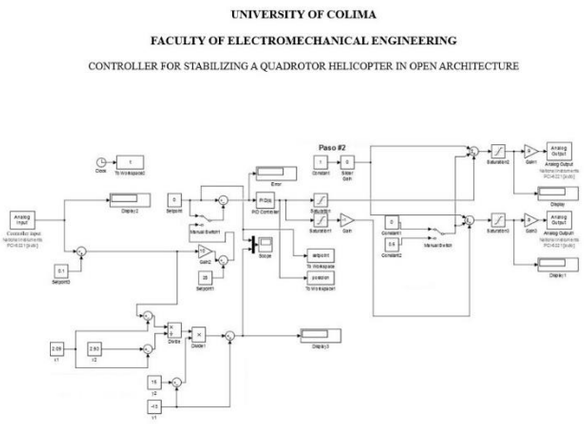

Figure 12
Diagram of the program developed in Matlab with the Simulink tool

Source: [Authors]

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Results

Visualisation of the control signals, collected from the commercial DJI NAZA MLITE controller, was performed using Matlab software and the Simulink tool. Using programming blocks, the communication between the software and the PCI 6221 data acquisition card was configured. Figure 13 shows the complete implementation of the system designed to read these signals.

Box 13

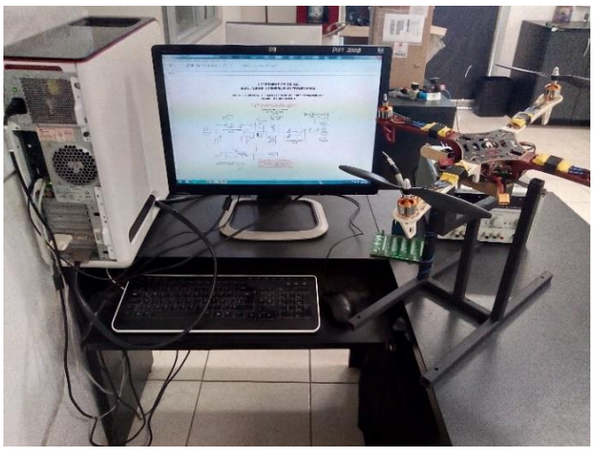

Figure 13
Signal reading equipment
Source: [Authors]

The first stabilisation tests were carried out on the pitch axis. To measure the degrees of tilt. The necessary settings were made in the program to display the pitch values in real time. Figure 14 shows the resulting stabilisation graph, where the ascending and descending peaks correspond to the perturbations applied during the test.

Box 14

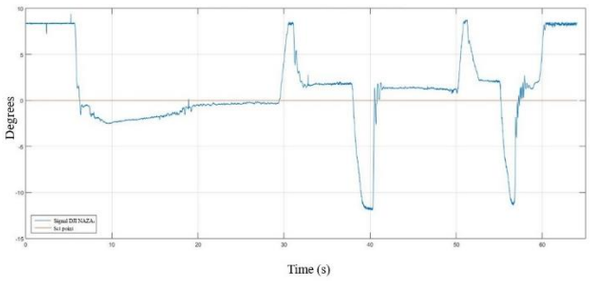

Figure 14
Quadrotor stabilisation graph with DJI NAZA MLITE controller
Source: [Authors]

Figure 15 below shows a comparative graph between the PWM signal generated for both motors and their response time with respect to the setpoint. In this test, the quadrotor was subjected to perturbations to observe the behaviour of both signals in the graph, as well as the degree of error of the DJI NAZA controller when adjusting to the setpoint. In the graph, the engine 1 signal is represented by the blue line, the engine 3 signal by the red line, the quadrotor stabilisation signal by the orange line and the system setpoint by the black line.

The result obtained in this test, using the commercial DJI NAZA MLITE controller, shows that the system has a margin of error of ± 2 degrees with respect to the setpoint, a consistent result in all the tests performed.

Box 15

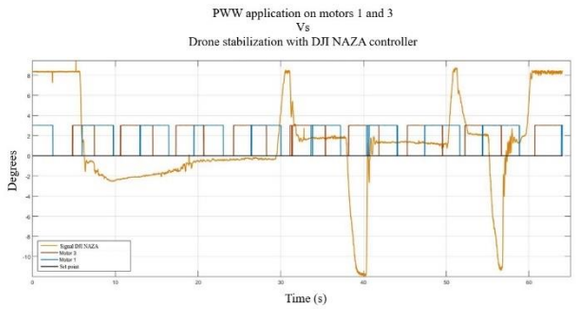

Figure 15
System signals with the DJI NAZA MLITE controller
Source: [Authors]

The results obtained by implementing the programmed controller in MATLAB software and the Simulink tool are presented below.

To carry out the signal reading and processing, it was necessary to link and make the corresponding configurations in the Simulink programming block, in accordance with the PCI 6221 data acquisition card. In this process, the sampling time, the amount of discretised data, the data to be excluded during the tests, as well as the input and output configurations with respect to the card were configured. In addition, the Arduino was programmed to generate the PWM signal modulation in real time, applying the controller to the quadrotor.

Figure 16 shows the assembly of the equipment necessary to carry out the tests with the controller.

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The computer with the designed program, a power supply to feed the implemented devices, and the quadrirrotor with the test base can be seen.

Box 16

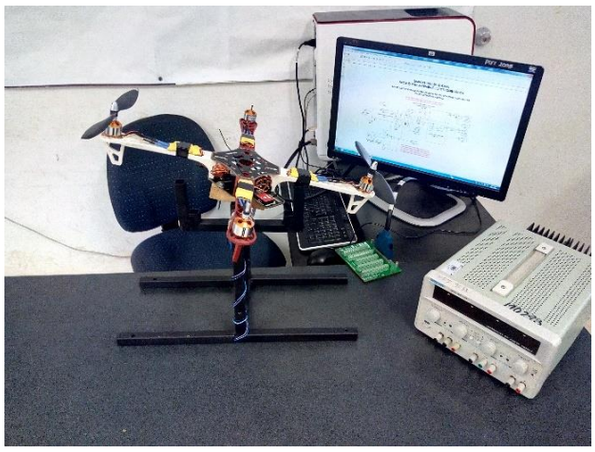

Figure 16
Team for the implementation of the controller designed in MATLAB with the Simulink tool
Source: [Authors]

Figure 17 shows the PWM pulse train applied as a control signal. This pulse train allows the pulse width modulation in the motors to be modified according to the indications of the controller, resulting in an increase or decrease in the voltage applied to the motors.

The graph shows both control signals: the blue signal represents motor 1, while the red signal corresponds to motor 3.

Box 17

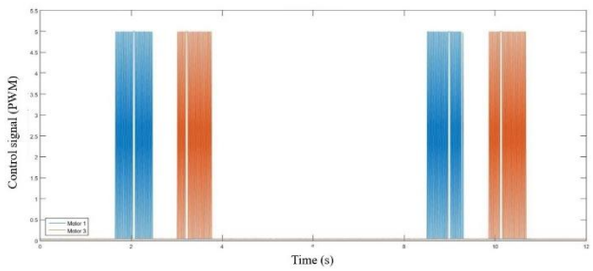

Figure 17
Signal of the controller designed in MATLAB with Simulink
Source: [Authors]

In Figure 18, the stabilisation plots of the quadrotor as a function of time using the controller designed in MATLAB along with the Simulink tool are presented.

These graphs show that the margin of error with respect to the setpoint is very close to that obtained in the tests carried out previously with the commercial DJI NAZA MLITE controller, ± 2 degrees.

Box 19

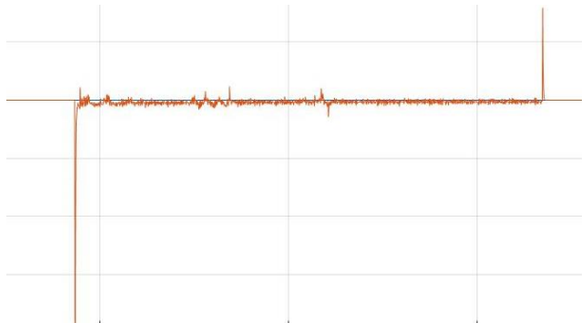

Figure 18
Stabilisation versus time graph
Source: [Authors]

It can be seen that the controller provides a fast response, bringing the quadrotor efficiently to its equilibrium point. The graph shows small overshoots, which are due to the incorporation of slight disturbances during the test. This shows that the response time of the system to these disturbances is minimal, highlighting its effectiveness in stabilisation.

Conclusions

The present research work resulted in the design and construction of an open architecture quadrotor prototype, intended for experimentation in the area of unmanned aerial vehicles. This prototype offers the flexibility to be controlled by various control techniques. In addition, its modular design allows components to be updated and replaced, avoiding obsolescence and ensuring its adaptability to new technologies.

Throughout development, multiple stabilisation tests were conducted using the commercial DJI NAZA MLITE controller as a reference. These tests allowed the collection of key data on the signals applied to the engines, providing a solid knowledge base for the design and implementation of proprietary controllers.

In the results chapter, the operation of the prototype was demonstrated using a classical PID controller, programmed in MATLAB Simulink.

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The data obtained included the margin of error in the stabilisation against perturbations applied to the system.

Finally, the implementation of other advanced control techniques, such as genetic algorithms, fuzzy logic and other innovative methodologies, is proposed for future research work to extend the capabilities of the prototype and explore new applications in the field of UAVs.

Authors' contribution

Charre-Ibarra, Saida: Contributed with the project idea, report writing and design.

Vidal-Ortega, Erik: Contributed to the design and testing of the prototype.

Gudiño-Lau, Jorge: Contribute to the programming, writing and revision of the report.

Duran-Fonseca, Miguel: Contribute in the testing, writing and revision of the report.

Availability of data and materials

Data used or analysed during this work are available on request.

Funding

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To the Faculty of Electromechanical Engineering of the University of Colima.

Abbreviations

CAD	Computer Aided Design
DAQ	Data Acquisition
PID	Proportional, Integral, Derivative
PTR	Rectangular Tubular Profile
PWM	Pulse Width Modulation

References

Background

Heartland Science. (2015). *Helicopter: Principles and history*. Heartland Science.

Hernández, L. A., Pedraza, J., Velázquez, G., Sotomayor, A. & Delgado, M. (2014). Diseño y desarrollo de un vehículo volador de cuatro hélices no tripulado de bajo costo. La Mecatrónica en México, 3(1), 23-36.

Basics

DJI (s.f.). Naza m-lite user manual.

Rawashdeh, Osamah & Yang, Hong & Abousleiman, Rami & Sababha, Belal. (2009). Microraptor: A Low-Cost Autonomous Quadrotor System. 10.1115/DETC2009-86490.

Quanser. (s.f.). Quanser: Innovate Educate.

Support

Gómez Ruiz, F. J. [2020]. *Vehículo aéreo no tripulado basado en Arduino y tecnologías open source de baja capacidad para la adquisición de datos y realización de misiones* [Tesis de licenciatura]. Escuela Técnica Superior de Ingeniería y Sistemas de Telecomunicación.

Guerrero, J. N. (2014). Implementación de un algoritmo de control para el levantamiento de un helicóptero de cuatro rotores. [Tesis de Maestría], Universidad autonoma de Queretaro.

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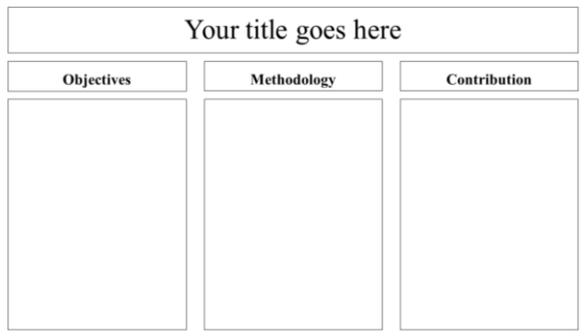

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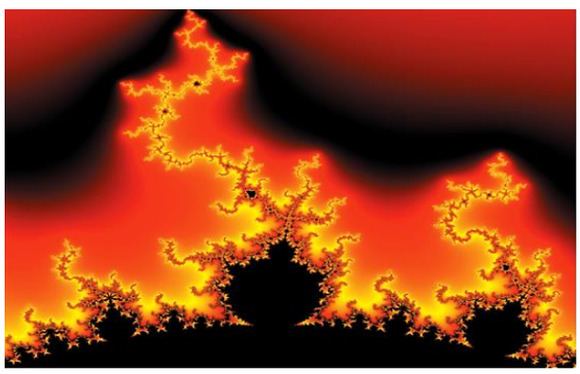

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