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Journal of Technological Development

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Presentation of the Content

In the first chapter we present, *Viable model of the Mexican legal system: A transdisciplinary systemic vision*, by PATIÑO-ORTIZ, Ana Alejandra, VILLAGRÁN-VILLEGAS, Luz Yazmín, MARTÍNEZ-CRUZ Miguel Ángel and ANZELMETTI-ZARAGOZA, Juan Carlos, with adscription in the Instituto Politécnico Nacional and Universidad Veracruzana, as the following article we present, *Simplified nonlinear rotational inertia model for the simulation and analysis of the characteristics of an unconventional VAWT type wind turbine with variable pitch*, by FRANCO-MARTÍNEZ, David, GARCÍA-BARRERA, Jesús, DÍAZ-SALGADO, Jorge and HUERTA-CHÁVEZ, Oliver M., with adscription in the Tecnológico de Estudios Superiores de Ecatepec and Tecnológico de Estudios Superiores de Tianguistenco, as the following article we present, *College student learning styles and interests in times of pandemic*, by ESPERICUETA-MEDINA, Marta Nieves, SÁNCHEZ-RIVERA, Lilia, CEPEDA-GONZALEZ, María Cristina and MIRELES-PALOMO, Jaqueline, with adscription in the Universidad Autónoma de Coahuila, as the following article we present, *Virtual laboratories, an educational resource as a strategy for quality educatio*n, by HERNÁNDEZ-LÓPEZ Vianney, LOPEZ-VALDIVIESO, Leticia, MARTÍNEZ-IZQUIERDO, Carlos Mario and NOTARIO-PRIEGO, Ezequiel, with adscription in the Instituto Tecnológico de Villahermosa.

Contet

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Viable model of the Mexican legal system: A transdisciplinary systemic vision

Modelo viable del sistema jurídico Mexicano: Una visión sistémica transdisciplinaria

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Abstract

In Mexico, the Legal System contemplates a broad set of agencies responsible to the justice imparting, therefore for its management it is necessary to have a systemic model that allows to contribute, in a more adequate way, to the entire set of subsystems; in such a way that the institutions responsible to administering justice are capable of accurately and expeditiously determining the results and conclusions in the areas responsible to the administration of justice. The implementation and application of models with a systemic approach, such as Viable Systems Models, allow us to respond to many problems at different integrated levels of abstraction of sociotechnical systems, such as those responsible to justice administration in Mexico. This research work purpose is to design a Viable Model for the Mexican Legal System, which will allow to provide justice delivery systems with a tool that streamlines, and facilitates the management, control and handling of the information used in the National Legal System. The systems approach application in the design of viable systems allows to unite different expert's views to give a comprehensive response to the analyzed cases.

Legal System, Viable system model, Sociotechnical systems

Resumen

En México, el Sistema Jurídico contempla un conjunto amplio de organismos encargados de impartir justicia, por ello, para su gestión es necesario contar con un modelo sistémico que permita coadyuvar, de una forma más adecuada, a todo el conjunto de subsistemas; de tal forma que las instituciones encargadas de impartir justicia sean capaces de determinar con precisión, y de manera expedita, los resultados y conclusiones en los organismos encargados de la impartición de justicia. La implementación y aplicación de modelos con un enfoque sistémico, como los Modelos de Sistemas Viables, permiten dar respuesta principalmente a muchos problemas en diferentes niveles integrados de abstracción de sistemas sociotécnicos, en la planeación y el control. El presente trabajo de investigación tiene como finalidad diseñar un Modelo Viable para el Sistema Jurídico Mexicano, el cual permitirá dotar a los sistemas de impartición de justicia de una herramienta que agilice, y facilite la planeación, gestión, control y el manejo de la información utilizada en el Sistema Jurídico Nacional. La aplicación del enfoque de sistemas en el diseño de sistemas viables permite cohesionar diferentes visiones de expertos para dar una respuesta integral a los casos analizados.

Sistema jurídico, Modelo de sistema viable, Sistemas sociotécnicos

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Introduction

The Mexican Legal System (MLS) is the set of legal norms in force and applicable in our Country, it´s supported by the Political Constitution of the United Mexican States, which is the fundamental and supreme Law of México. (SCJN, 2006). Heylighen reflects on society as a global system, supported mainly by systems theory and cybernetics, seeks to give a holistic and autopoietic treatment to the social object (Heylighen 2017), (Maturana, 1980), that is, it refers to the self-organization in living beings. The systems approach allows the parts and interactions study that make up a system and its environment (Checkland, 2006).

Ashby considers Cybernetics as the study of systems open to energy but closed to information and control (Ashby, 1954), therefore, the cybernetics fundamental concept is the "difference" between information obtained from the measurements of environment energy, with respect to information desired internally; both are totally different or that with time something has changed. The change is a phenomenon that moves with time (Ashby, 1954), (Wiener, 1958), (Sabine, 1994).

A basic principle in each institution or company is that they have the processes of Inputs, Production and Outputs, which define the workflow (Vander, 2004), (Davenport, 1992). Likewise, this allows us to model the processes and their interrelations with techniques that show us to a global and comprehensive vision. We must consider to generate strategies and change or design processes is necessary to have timely and adequate information, which can be the competition core, since it is what allows organizations to succeed (Prahaland, 1990).

To develop a general model in general and a particular Viable Model, the problems in the relevant systems of the organization must be identified and analyzed to determine or generate changes and actions to improve or solve the problems. (Beer, 1989), (Ashby, 2017) (Aguilar, 2021)

This research work purpose is to design a Viable Model, which allows providing justice delivery systems with a tool that streamline and facilitates planning management, control and information used in the law enforcement agencies, specifically at the national level.

The systems approach application will make it possible to unite the different visions of theoretical and practical experts, to give the most adequate and quick answers to the case analyzed and to development of Viable Systems Models (VSM).

A. General Systems Theory (GST) and Systems Engineering

GST is an interdisciplinary theory based on the integration and reciprocal dependence of all disciplines. Bertalanffy describes it as a methodological approach that allows the explanation and description of the phenomena that occur in the reality and what the behavior of said reality will be like in the future. The GST studies the systems and their organization, their subsystems, their interrelations, their hierarchical levels, their resilience, their autonomy, their identity and their conservation, the rules of their organization and growth, the conditions of their conservation, their possible or probable states, as well as their disorganization and destruction (Bertalanffy, 1968).

In fact, Systems Engineering is a systematic and scientific approach to represent reality through designed models, as well as a stimulating practice oriented towards forms of interdisciplinary work (Ackoff, 2006), (van Gigch, 1987). Systems are open, since they interact with other systems outside their limits or borders, which are called the environment (Wilson, 1993).

Methodology

The methodology used in this research is the Checkland methodology (for soft systems), it can be described as an analysis process that uses the concept of a system. The methodology first investigates the situation (poorly structured problem) and then takes actions to improve activities; real world and systems thinking (see Fig. 1). The methodology is a 7th process (Checkland, 2006):

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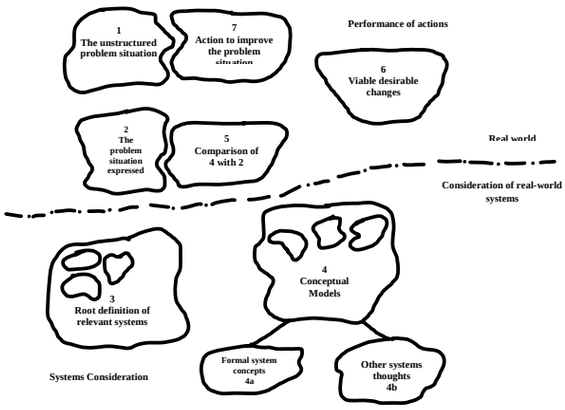

Figure 1 The Soft Systems Methodology
Source: (Checkland, 2006)

In Beer´s methodology development, the Viable System Model (MSV) in stage 4b is used, which is a cybernetic model that allows the diagnosis and design of human organizations. For Beer, institutions such as: home, school, cities, companies, regions or countries are not only more or less abstract entities that we recognize and to which we give a name; they are dynamic and surviving systems; Beer establishes that in a viable system there are five functions (subsystems) so that it conserves its identity and can respond to a dynamic environment (Beer, 1989), (Beer, 1966) for long-term survival (Beer, 1975).

Stafford Beer developed a model based on the brain physiology study, where he obtained some principles for the control theory of administrative systems (Beer, 1989).

Development

A. Current Situation of the Mexican Legal System and its classification

The Mexican Legal System is made up of legal norms that are applicable in this country, understanding legal norms as the rules that govern the conduct of good behavior of individuals in a society, which have the following characteristics: they are bilateral, external, heteronomous and coercive.

The way in which the rules that constitute the Legal System appear is through the so-called Formal Sources of Law, which can be defined as the process of creating legal norms; Mexican Law contemplates the legislation, jurisprudence, custom, doctrine and general principles of law.

Each of the legal norms has characteristics that make it different, constitute the foundations of all legal order (see Fig. 2).

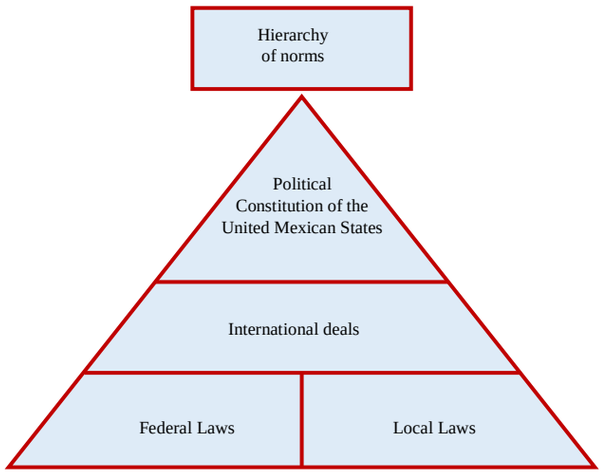

Figure 2 The Hierarchy of Standards
Source: (SCJN,2006)

To systematize the norms and make their scope more evident, they are classified, among other ways, according to their material, hierarchy and spatial areas of validity (see Table 1).

Public Law	Penal Electoral Procedural Administrative Constitutional Public International
Private Law	Mercantile Civil Private International
Social Law	Social Assistance Social Security Agrarian Economic From work
Other	Computer scientist

Table 1 Branches of Law
Source: (SCJN,2006)

B. Justice Administration System

The Justice Administration System is integrated as shown in Fig. 3.

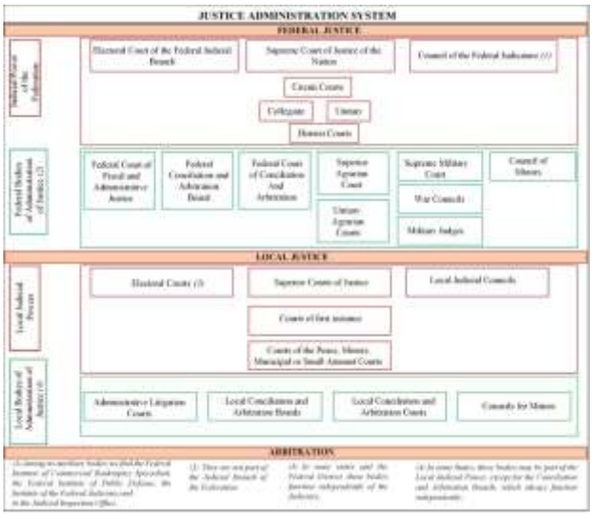

Figure 3 Justice Administration System
Source: (SCJN,2006)

C. Diagnosis

To carry out the diagnosis, the first two stages of the Checkland methodology are developed.

1) Situation of the unstructured problem

The Mexican Legal System (MLS) regulates the organizations of individuals in a society, maintains harmony in it; It establishes rules for living which have regulated the conduct of individuals in society; in such a way that, to organize the peoples that are growing every day, the institutions that make up the Legal System are born, establishing laws and decrees applicable to the individuals that simulate said society (see Fig. 4).

In Mexico there is a performance problem of the authorities that simulate the MLS, especially in the justice administration, which becomes more serious and complex when the MLS is not reliable for society; The proof of this is in the crime's statistics committed and the complaints that are not made because they considered a waste of time (ENVIPE, 2018).

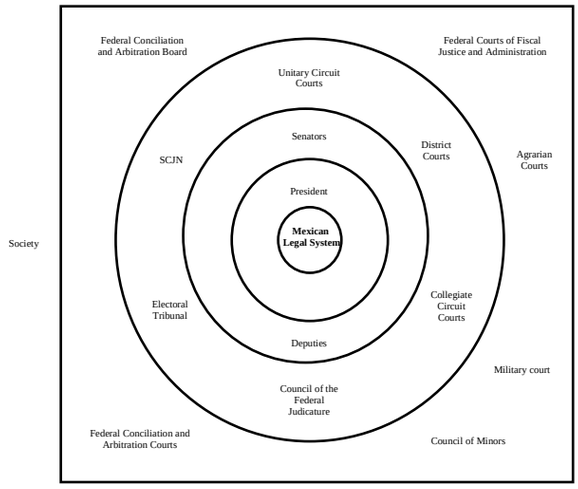

Figure 4 The Mexican Legal System and its environment
Source: Self Made

The Mexican Legal System is divided into three powers, which, in turn, are made up of various institutions (see Fig. 5), each having a specific task within it; However, they all pursue the same common goal: to guarantee the well-being of individuals in society, favoring coexistence among them and regulating the behavior of the people who make it up.

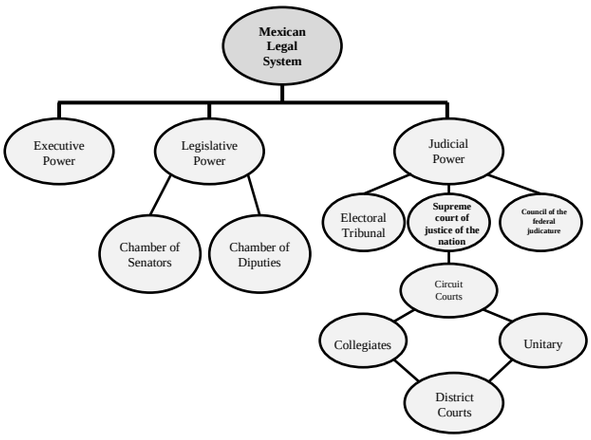

Figure 5 Structure of the Mexican Legal System
Source: (SCJN,2006)

2) Rich vision of the problem situation

In Fig. 6, a representative model of the problem situation that exists in the Mexican Legal System is shown; In it, a richer comprehensive vision is observed and it is structured through a set of problems related to the main activities carried out in the Justice Administration System in Mexico, thus, the problems obtained in the diagnosis and interpretation of the rich vision images are integrated into three groups, which are:

a) Bad relationship between the powers and with society in general

The improvement of the Mexican Justice System is difficult to achieve if it does not go through the strengthening of the union powers, since they are responsible for responding to the demands for the justice administration in the country. This problem occurs because there is no real balance between federal powers with local areas, which makes it difficult for tasks to be carried out effectively and efficiently. In addition to the above, the justice system has been strongly questioned by Mexican society, due to the low credibility and trust that it has in the system, since most legal processes take a long time to be resolved, which has the consequence that citizens feel that there are no quick responses to their demands, that matters are not decided impartially and that impunity and corruption persist in the judicial system.

b) Financial Resources misused

A basic instrument available to the union powers to fulfill the tasks to which they are obliged, is the budget that is approved each year, however, the problem that arises is that it does not reach or is misused, since most of the time it is not prioritized in the needs that society presents, and as a consequence, if there are not enough resources, there cannot be an adequate and qualified number of judicial areas or public servants to attend to the demands of justice; nor the possibility of expanding or improving existing spaces, nor will it be possible to acquire new technologies, nor have new alternative mechanisms to provide a prompt and expeditious solution to citizens.

c) Lack of planning, training and updating

The authorities main function is to resolve the controversies that are submitted to their knowledge, as required by Mexican law, that is, promptly, expeditiously and impartially; But, to comply with this, it is necessary to have good planning by the institutions responsible to imparting justice, with an adequate number of people and with good administrative support to keep them in office, the suitable personnel who are constantly updated and training, the appropriate facilities for the type of controversy exposed.

In addition to everything, a very important aspect is that it must have the appropriate technologies to simplify and faster the work of the subsystems that make up the Mexican Legal System.

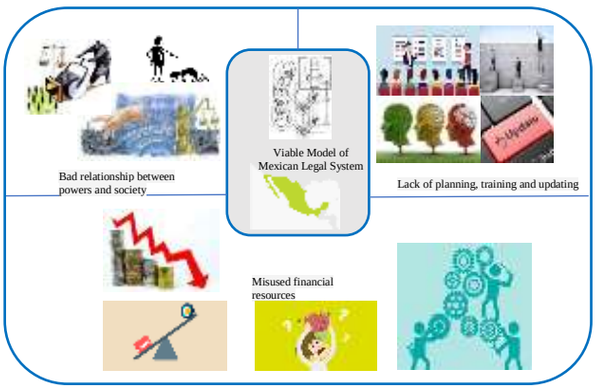

Figure 6 Rich vision of the problem situation.
Source: Self made

D. Model design

For the model construction and the relevant systems determination, the Checkland methodology is used due to its flexibility for "soft" systems, in addition to allowing it to be carried out in the order that fits the specific problem to be treated.

1. Root definition of the relevant systems

The mnemonics CATWOE (Checkland) is used to guarantee that the most important characteristics are considered, with which we identify the elements involved:

a) C = Customer, are the users.

- Society
- Lawyers
- Authorities that represent people as Public Ministry

b) A = Actors or agents, are responsible to transforming information inputs into outputs.

- President of the Republic
- Deputies
- Senators
- Ministers of the SCJN
- Magistrates
- Judges

c) T = Transformation, the main output will be the viable model of the Mexican Legal System.

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d) W = Weltanschauung, vision of the world, is the vision of those involved (see Table 2).

Mexican Legal System	
Positive: – Relationship with the environment – Appropriate laws – Financial resources – Human resources	Negative: – Corruption – Bureaucratism – Bad relationship between the powers – Misused resources – Lack of training – Poor planning
Society	
Positive: Access to the legal system	Negative: Lack of confidence in the legal system Crime growth

Table 2 World view
Source: Self Made

e) O = Owner (owner), is the owner of the MLS, who makes the decision and has the power to decide who is going to manage the country.

f) E = Environment, is the environment; The subsystems that make up each of the three powers of the nation, which have already been mentioned previously, as well as society in general, are considered. It was found that the relevant systems of the Mexican Legal System, specifically the Justice Administration System, are made up of seven relevant interrelated systems that make it work; these are:

2. Value system (axiological)

It will allow to develop, in an ethical, dignified and honest way, the functioning of the systems.

3. Research and creation system

System responsible for the creation of laws through the investigation of the needs that society has as it grows, in this system falls partly the responsibility for the malfunction of the quality of the laws that make up the MLS, since is responsible to the correct creation, modification, repeal, etc. of the applicable laws for the proper functioning of life in society.

4. Knowledge system

Set of laws, rules, regulations, technology, specific infrastructure for each case, required by the total system to be able to apply and develop the tasks of each specific case that reaches the authorities.

4. Quality and performance system

System responsible for the correct application of the law to the specific case. Fundamental system of the legal system since, it is responsible to correctly applying the laws to the individuals who violate them within society.

5. Planning and control system

System responsible for planning and controlling the proper functioning of the authorities that make up the justice administration system.

6. Customer system (company)

System that makes the system work in its entirety, since it is the system to which the authorities must satisfy their needs; the aim is for clients to maintain a relationship of trust with justice.

7. Environment system

System that provides feedback to the entire system, since it influences and reacts to variations of the total system or of any of its components, the environment influences, criticizes and reacts to the good or bad functioning of each one of the authorities that make up the MLS.

Once the relevant systems have been found, the conceptual model designed to apply to the Mexican Legal System is presented (see Fig. 7).

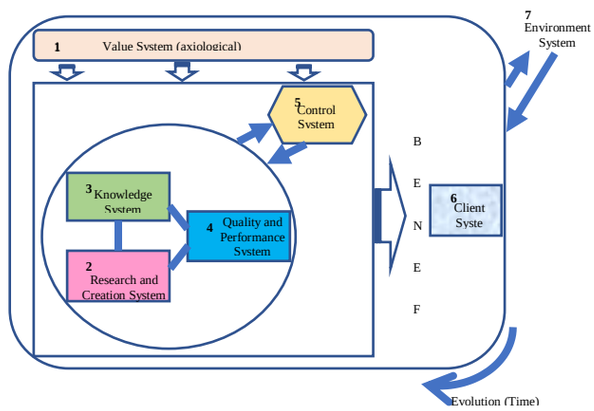

Figure 7 Conceptual model of the Mexican Legal System
Source: Self Made

2) Design of the Viable Model of the Mexican Legal System (MLS)

Once the relevant systems have been found, they must be considered for the design and implementation of the Viable System Model, for which their construction is proposed below.

Divisional control system - System 1

They are all the units in responsible to carrying out the basic organizational tasks and activities to achieve the correct performance of the Federal Judicial Power (FJP). System 1 is formed by the District Courts subsystem.

Comprehensive control system - System 2

System 2 ensures the connection and stability between the divisions of the organization corresponding to System 1. The coordination of activities is fundamental in the structure of any organization. System 2 has the responsibility of advancing or delaying procedures, programs and processes, making modifications or adaptations according to the client's needs. In such a way that, to solve all kinds of deviations in the operation of the system, rules and policies related to the activities of the system are followed. System 2 must include the following activities of the information flows towards system 3: Coordination, Regulation, Update, Discipline and Training.

System 2 is represented by the Federal Judiciary Institute, which is a body belonging to the Federal Judicial Council, in charge of formation, training and updating the members of the Federal Judicial Power and those who aspire to be part of this, supervising the conduct and good performance of the human capital that makes up the system; It also carries out the research work that is needed for the development and improvement of the administration of justice.

Internal homeostasis system - System 3

System 3 is responsible for the control and System 3 * for conducting the corresponding audits. In this system, decisions must be made about programs, projects and action plans; Decision-making must consider the advantages and disadvantages, as well as the opportunities and threats.

This system is represented by the Council of the Federal Judiciary, since it is the body in charge of the administration, surveillance and proper functioning of the Courts and Tribunals. System 3 * is represented by the Comptroller of the Judicial Power of the Federation, since it is responsible of the powers to control and inspect the administrative operations that govern the JPF, as well as to prepare audits of the same.

External homeostasis system - System 4

System 4 is responsible for looking to the future of the organization; It is capable to detecting the appropriate information and transmitting it to system 1, which allows the adaptation and learning of system 1 according to the environment, as well as the restructuring of systems 2 and 3.

The main task of system 4 is to demand that external changes be considered and recognized to have a true diagnosis. System 4 must face present and future changes, developing strategies, goals and objectives, this system is represented by the Judicial Power of the Federation.

Prevention system - System 5

System 5 must integrate all current activities, considered by system 3 and future needs considered by system 4, to ensure the balance between systems and guide decision-making, for which it considers: the mission, vision and values. System 5 is represented by the Supreme Court of Justice of the Nation, since in the MLS, the administration of justice is coordinated through it. It is the highest court in the country, and it is responsible for ensuring the order established by the Constitution and maintaining the balance between the various government institutions.

Considering in an integral way the vision of the 5 previous systems, a Viable System is obtained that allows a global and integral vision of the MLS; that, by organizing its activities, formulating strategies, programs and processes, ensure their viability and good performance, so that the entire system can function effectively in pursuit of its objectives, and thus be able to improve the client's quality of life, that is, of society, since it is for this that it has to function properly. (see Fig. 8).

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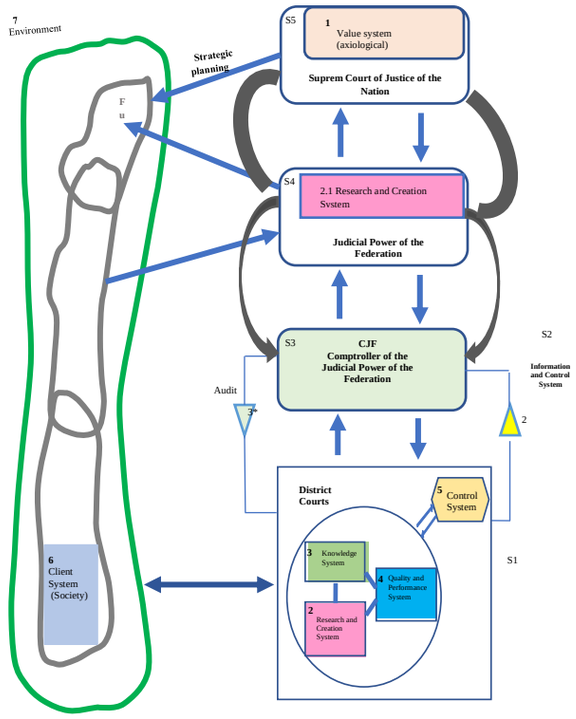

Figure 8 Viable model of SJM.
Source: Self Made

Table 3 shows the MSV Systems with which the MLS is integrated, as well as the relevant systems that are involved in each subsystem, it should be noted that the axiological or value system must permeate the entire system, therefore, we can say that there is a level of correspondence between these.

	Viable System Model	Mexican Legal System	Relevant Functions / Systems
System 1	Divisional control	A-District Courts	Operations Research and creation system (2) Knowledge system (3) Quality and performance system (4) Control system (5)
System 2	Comprehensive Control	Institute of the Federal Judiciary	Control
System 3*	Internal Homeostasis	Council of the Federal Judicature Comptroller of the Judicial Power of the Federation	Administration Auditor
System 4	External Homeostasis	Judicial Power of the Federation	Planning Research and creation system (2.1) Client system (6) Environment system (7)
System 5	Prevention system	Supreme Court of Justice of the Nation	Identity Value system (1) Environment system (7)

Table 3 Comparison of the components of the Viable System Model with those that make up the Mexican Legal System
Source: Self made

3) Proposal for a complementary solution

In the development of the model, it was found that it must have the appropriate technologies to simplify and make the work of each of the subsystems that make up the Mexican Legal System more effective and faster; Therefore, it is necessary to use a viable system that allows conflict resolution in a faster and more efficient way.

Therefore, it is proposed to implement within system 1 of operations, in addition to the existing ones, a subsystem called Alternative Justice, in such a way that there would be two subsystems in system 1:

A- District Courts
B- Alternative Justice

But: what is alternative justice and how would it help solve the problem?

Alternative justice, known as Alternative Conflict Resolution Means (ACRM), is a set of conflict resolution procedures carried out outside the judicial sphere, where the use of force does not intervene; Thanks to the use of alternative justice, people solve their conflicts outside the jurisdictional process, among these we find: conciliation, mediation and arbitration.

Taking this as a basis, it is proposed, in addition to the Viable Model, that in any judicial process, with some exceptions, before the jurisdictional stage, there is a mandatory stage of conciliation, that is, that the parties in conflict, can resort to alternative justice to solve their controversies in a short time, in such a way that if within that time the parties reach an agreement, the respective agreement is signed and this will have the effect of a sentence, so its compliance must be mandatory. In this way, alternative justice will allow dejudicializing many matters that are turned over to the courts or tribunals, thereby reducing the time of legal processes.

Considering the above, when implementing subsystem B to operations system 1, the viable MLS model would be as shown in Fig. 9 and Table 4.

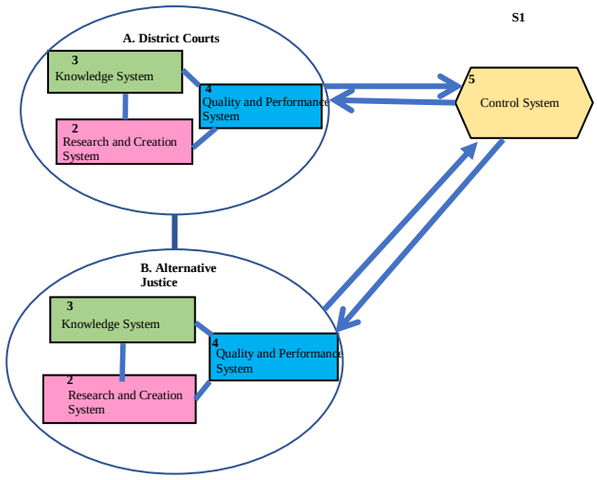

Figure 9 System 1 of the Viable Model of the Mexican Legal System
Source: Self Made

	Viable Model System	Mexican Legal System	Relevant Functions / Systems
System 1	Divisional Control	A-District Courts B-Alternative Justice	Operations Research and Creation System (2) Knowledge System (3) Quality and Performance System (4) Control System (5)

Table 4 Comparative table of subsystem 1 of the Viable Model of the Mexican Legal System
Source: Self Made

Conclusions

The Viable Model provides the basis for designing proposals for alternative models that can be applied to any organization with the same similarities, such as services, quality, technologies, etc. Likewise, considering as a foundation the methodology of soft systems of Peter Checkland.

The relevant systems found allow the design and adaptation of each system that comprises the viable model, whether in operation, coordination and / or administration.

The viable model designed, in this research, has the adaptability capacity to make the pertinent changes, as we saw in system 1 of operations, where there is a need to include a subsystem that helps the legal processes to be filtered and selected, which will allow greater speed and more efficiency.

With the global problem that is being experienced due to the pandemic, the Mexican Legal System was forced to use technologies to be able to solve urgent conflicts, even with virtual audiences, however, there is still a large gap on this issue; That is why the viable model proposed in this research has the capacity for the MLS to effectively satisfy the needs of those it should serve.

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Simplified nonlinear rotational inertia model for the simulation and analysis of the characteristics of an unconventional VAWT type wind turbine with variable pitch

Modelo de inercia rotacional no lineal simplificado para la simulación y el análisis de las características de un aerogenerador de tipo VAWT no convencional de paso variable

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Abstract

This paper shows a double multiple stream tube model coupling to a rotational inertia model. It allows the simulation and analysis of the characteristics of an unconventional vertical-axis wind turbine (VAWT) with Variable Pitch. This implementation permits to employ a stationary response of the wind turbine calculated across the main characteristics of output torque based on experimental aerodynamic coefficients and the Reynolds at each station, can be transformed into a transient response by a simplified non-linear rotational inertia dynamic model to predict the start-up, idle, stabilization and sudden stop of our device.

VAWT, Variable pitch angle, Multiple stream tube model, Rotational inertia

Resumen

Este trabajo se presenta una técnica numérica del método de múltiples tubos de corriente estacionario-acoplada a un modelo de inercia rotacional, para la simulación y análisis de las características de un aerogenerador tipo VAWT no Convencional con Paso Variable. Dicha implementación permite que una respuesta estacionaria del aerogenerador calculada a través de las principales características de torque de salida basados en coeficientes aerodinámicos experimentales y el Reynolds de cada estación, pueda ser transformada en una respuesta transitoria a través de un modelo dinámico de inercia rotacional no lineal simplificado para el pronóstico de la puesta en marcha, ralentí, estabilización y paro repentino de nuestro dispositivo.

VAWT, Ángulo de paso variable, Modelo de múltiples tubos de corriente, Inercia rotacional

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1. Introduction

To date, several studies have investigated different aerodynamic models to describe the static behavior of the VAWT with straight blades type Darrieus. These models are suitable to identify the optimal design parameters, performance prediction, and standing behavior of a vertical-axis wind turbine [1].

Various studies have reported different mathematical models of vertical axis wind turbines, one of these and the most applied is the Double Multiple Stream Tube. It allows to obtain the wind turbine response in a steady state to find the torque average of a wind turbine [10]. The Vortex model was another important mathematical mode, it employed power flow models based on the calculation of the speed field around the wind turbine through the influence of vorticity on the wake formed by the blades [10]. Hirsch and Mandal reported the cascade model [10], it applied the principles of connecting two cascade subsystems to the VAWTs and can also be used for different turbomachine types.

Different theories exist in the literature regarding to the purely mechanical solutions and have been reported to improve the efficiency of the wind turbine. These solutions were proposed without any dynamic model of the wind turbine [20, 21 and 22]. Mechatronic solutions have also been stated and proposed a closed loop control of the pitch angle from the measurement of the turning angle. Unfortunately, these dynamic models were not complete, and their analysis were incomprehensible [16,17 and 18].

It is important to mention that these mechatronic solutions have concentrated on the pitch angle variation method. Because it has been recognized as an attractive solution to improve the performance of vertical axis wind turbines in a theoretical way. These improvements have mainly consisted of: (i) the analysis of the tangential force coefficient with both negative and positive fixed angles of the pitch angle, (ii) the analysis of the tangential force coefficient comparing fixed pitch angles vs optimized angles and (iii) the determination of the angular positions where the wind turbine has greater torque for a given pitch angle [10].

2. Static Model

2.1.- Model with a single stream tube (Single Stream tube Model). This model fundamentally contemplates that the wind speed (V) is constant over the turbine [1], considering a single current tube (see Figure 1).

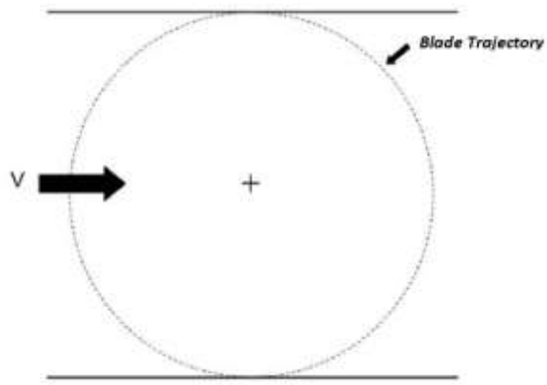

Figure 1 Single Stream tube Model
Own Elaboration

According to the wind direction and angular position of each wind turbine blades in this single stream tube model can be defined: the angle of attack and the lift and drag forces and with them the lift and drag coefficients, respectively.

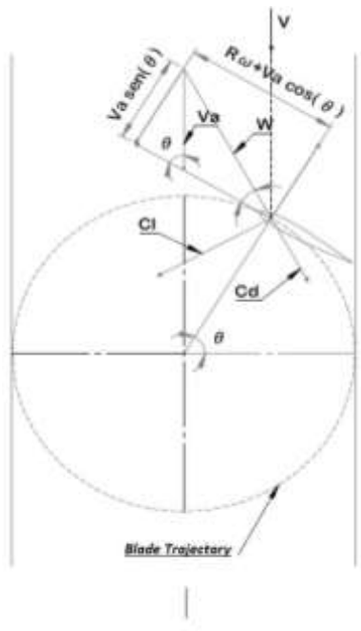

Figure 2 Single Stream tube and angle of attack components
Own Elaboration

The angle of attack α can be obtained by its geometric components, they are represented in Figure 2, so that:

$$\alpha = tan^{-1}\left(\frac{\text{Va}\, sen(\theta)}{\text{R}\omega + \text{Va}\cos(\theta)}\right) \quad (1)$$

While the relative velocity W is obtained by:

$$W = \sqrt{(Va\, sen(\theta))^2 + (R\omega + Va\, cos(\theta))^2} \quad (2)$$

Based on the actuator disc model, the induced velocity V_a can be defined as:

$$V_a = V_\infty(1 - a) \quad (3)$$

Where ω is the angular velocity, θ the angular position and a is the induction factor. Correspondingly, the Normal C_n and Tangential coefficients can be calculated C_t through the C_d and C_l lift components, which are specific to each airflow (Figure 3), so that:

$$C_n = C_l \cos(\alpha) + C_d\, sen\,(\alpha) \quad (4)$$

$$C_t = C_l sen(\alpha) - C_d \cos(\alpha) \quad (5)$$

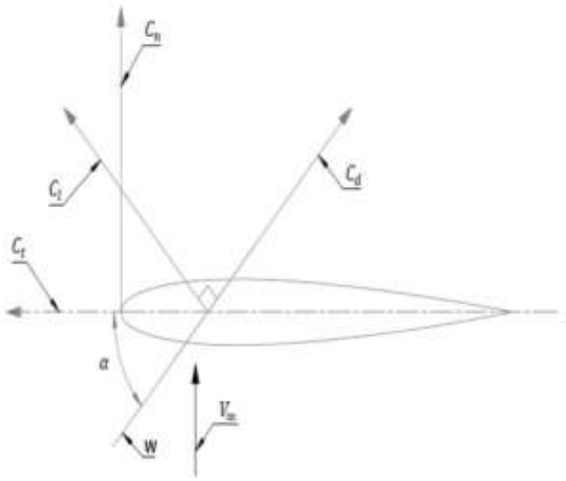

Figure 31 Coefficient Normal ($\boldsymbol{C_n}$) and Tangential ($\boldsymbol{C_t}$) acting on a blade
Own Elaboration

2.2 Model of multiple stream tubes

This model is the generalization of the single-tube model by considering multiple stream tubes in the blade sweeping area. The main difference between this model and the single stream tube model is that for each stream tube there are different induction rates. This means that each stream tube has its own induction velocity (Figure 4). Therefore, the results are more accurate as more stream tubes are considered in the calculation of average wind turbine torque.

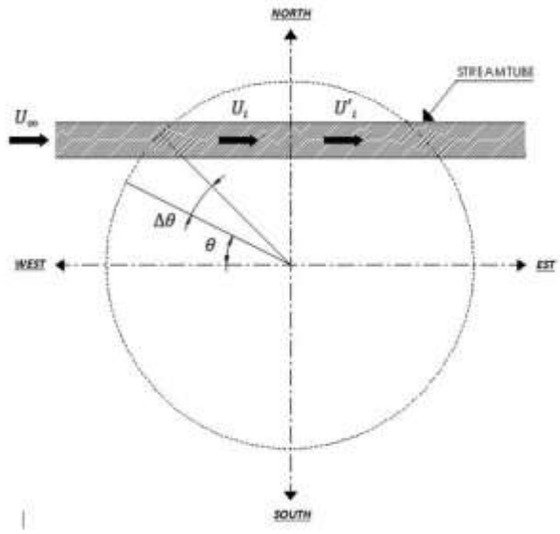

Figure 4 Multiple stream tube theory
Own Elaboration

In the next section the double tube model with multiple airflow currents is used to establish a numerical model. It permits to obtain the forces and moments produced by the wind turbine blades from the input parameters both in a stationary and transient state.

2.3 Implementation of the algorithm of the Double Multiple Stream Tube model

This algorithm is employed to compute the average torque of a VAWT of straight blades from 3 main input parameters (Figure 5) which are: (i) air velocity V_∞, (ii) angular velocity ω, and (iii) radius of the wind turbine R.

By given these input parameters, the algorithm calculates angle of attack, and lift and drag coefficients (Figure 15) using a two-dimensional interpolation, which are dependent on the Reynolds number. For each stream tube, an iteration process is performed to identify: (i) the induction factor a, (ii) the relative wind speed, (iii) the Reynolds number, (iv) the angle of attack, and (iv) the normal and tangential forces.

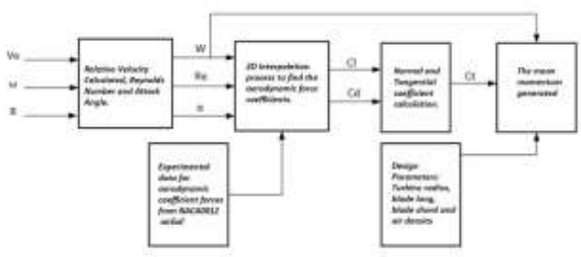

Figure 5 Block diagram of the algorithm
Own Elaboration

Drag and lift coefficients data of the NACA0012 airflow were obtained by experimental data conducted by Sandia Laboratories [13]. Such data is stored in ROM memory in the form of arrays within a function designed to interpolate the C_l and C_d parameters for a specific angle of attack and Reynolds number. The drawbacks of this method are: (i) the algorithm requires iterations for the calculation of the induction factor to each tube, and (ii) that the calculated average torque is the value of the stationary state response.

The main objectives of the simulation of the algorithm in Matlab are: (i) to analyze the behavior of the average torque in both the high-speed zone and the low-speed zone, this at different speeds with a constant T.S.R. and (ii) to check the behavior of the average torque in a revolution with a constant angle of attack.

2.3.1. Testing

The following tests were done to obtain the stationary responses of angular-torque position and angular position-angle of attack, this at different wind speeds with a fixed T.S.R. without modification of the angle of attack: (i) Static open-loop testing with the designed wind turbine, (ii) static closed-loop testing with a proposed control strategy, and (iii) transient response testing with three test input signals.

To obtain these results, the following simulation parameters are established (Table 1): initial angle of attack, number of Stream tubes, wind speed, angular velocity and T.S.R. keeping the T.S.R. fixed and modifying the wind speed and the angular speed of the wind turbine.

Simulation parameters	Test 1	Test 2	Test 3	Test 4
Initial angle of attack.	0º	0º	0º	0º
Number of Stream tubes.	20	20	20	20
Wind speed.	5 m/s	10 m/s	15 m/s	20 m/s
Angular velocity.	10.5 rad/s	21 rad/s	31.5 rad/s	42 rad/s
T.S.R. (dimensionless)	4.2	4.2	4.2	4.2

Table 1 Simulation parameters at different speeds and with fixed T.S.R.

The parameters described in Table 1 are established to analyze the behavior of the wind turbine at low speeds. Four tests are proposed at different speeds below 20 m/s and with a constant T.S.R.

Alternatively, in this first static analysis the test is performed with a pitch angle equal to zero, to analyze the behavior of the vertical axis wind turbine to open loop and locate the values where the torque is maximum and minimum with respect to the angle of attack and the angular position. For this we obtain the graphs of: (i) angular position θ vs Torque and (ii) angular position θ vs angle of attack (Figures 6-9) in all four cases.

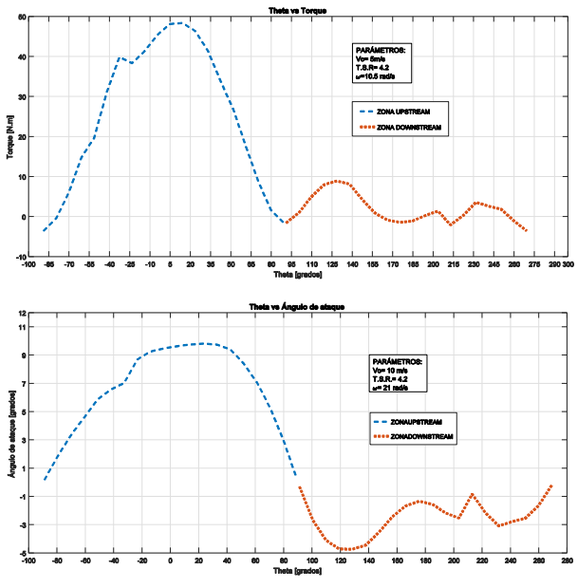

Figure 6 a) Torque Curve vs Angle of Attack and b) a) Theta Curve vs Angle of Attack Test 1
Own Elaboration whit MATLAB

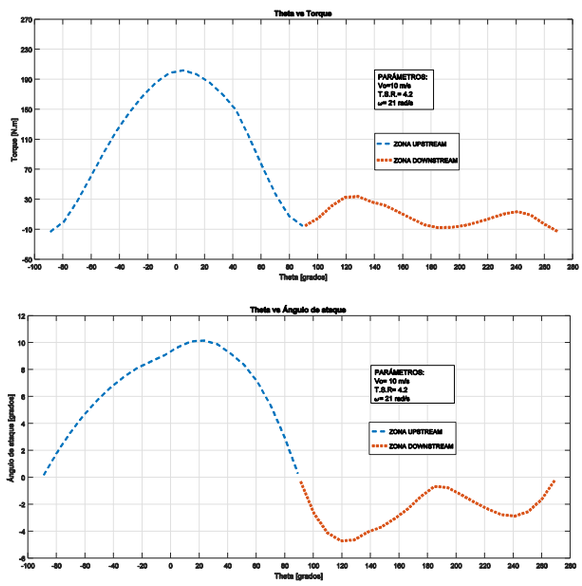

Figure 7 a) Torque Curve vs Angle of Attack and b) a) Theta Curve vs Angle of Attack Test 2
Own Elaboration whit MATLAB

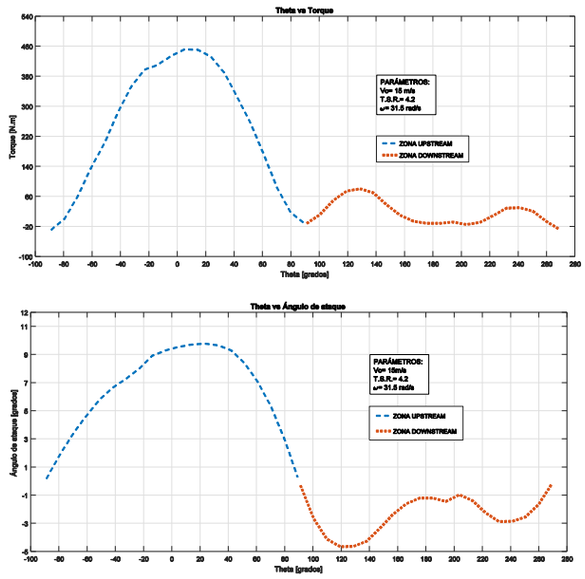

Figure 8 a) Torque Curve vs Angle of Attack and b) Theta Curve vs Angle of Attack Test 3
Own Elaboration whit MATLAB

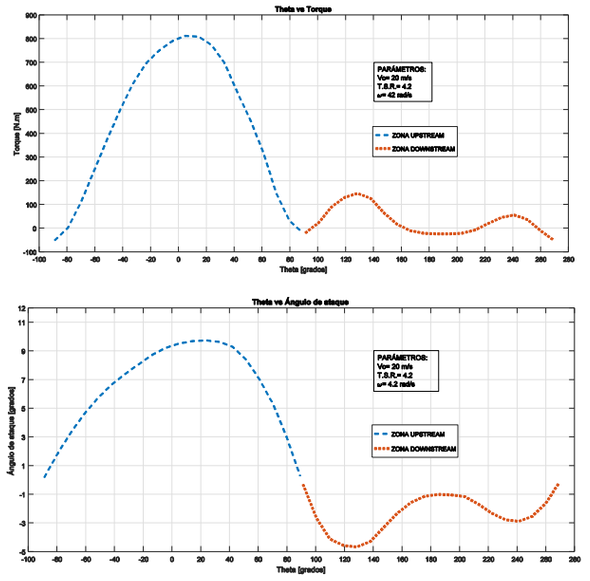

Figure 9 a) Torque Curve vs Angle of Attack and b) Theta Curve vs Angle of Attack Test 3
Own Elaboration whit MATLAB

As can be seen in the Theta vs Torque curves of Figures 6a), 7a), 8a) and 9 a) and the Theta vs Angle of Attack curves of Figures 6b), 7b), 8b) and 9b) the shapes of the curves at different speeds are very similar, giving the maximum torque in an angular position of between 0º and 20º that correspond to an angle of attack between 9º and 10º, while the minimum torque occurs in an angular position around 270º which corresponds to an angle of attack of between -2º and 0º.

If the four curves are superimposed on a single graph (Figure 10) this behavior can be seen more clearly and it can also be concluded that: (i) the angle of attack that generates the greatest torque is between 9º and 10º while the lowest between -2º and 0º, regardless of the wind speed and (ii) the torque generated is proportional to the square of the wind speed. These conclusions with valid with a constant T.S.R. of 4,2.

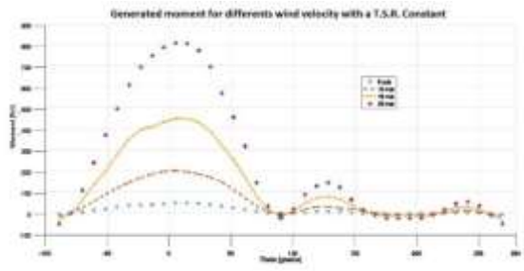

Figura 2 Theta vs torque
Own Elaboration whit MATLAB

3.-Implementation of the simplified nonlinear Rotational Inertia Model

To perform the dynamic tests, it is proposed a second-order dynamic model of rotational inertia type with viscous friction (Equation 6), where the excitation torque is calculated with the help of a function in Simulink written in MATLAB. The dynamic model is used for both the high and low speed zone.

$$\ddot{\theta}(t) = \left(-\frac{B}{J}\right)\left(\dot{\theta}(t)\right) + \left(\frac{T}{J}\right) \qquad (6)$$

The algorithm requires as inputs the angular position and velocity generated by Simulink's integrating blocks and wind speed. These inputs are used for the calculation of the relative wind speed, Reynolds number and angle of attack for each angular position.

Subsequently, the system performs a two-dimensional interpolation with respect to the angle of attack and Reynolds number to obtain the drag and lift coefficients of the blade and with it the tangential and normal coefficients in each angular position. To obtain the average torque of the turbine requires the tangential coefficient and design parameters which are: radius of the turbine, length and rope of the blade and the density of the air.

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Finally, the average torque is used in the dynamic model in conjunction with the rotational inertia and viscosity coefficient of the system for the calculation of angular acceleration. This model allows to determine the transient response of the wind turbine and thus analyze the dynamic behavior of the system at different wind speeds. The answers that can be obtained include: (i) the torque generated by each blade and by the wind turbine, (ii) the angular position, (iii) the angular velocity, (iv) the normal force and (v) the tangential force of each blade.

Once the methodology used for the implementation of the static and dynamic models of the wind turbine has been described, in the next chapter, we proceed to propose a prototype of a wind turbine and to carry out tests in simulation of the static and dynamic behavior of said wind turbine.

Static closed-loop testing with a proposed control strategy

The stationary results obtained in the previous simulations show that the maximum torque is generated with an angle of attack around 10º and the lowest around 0º, at least for a constant T.S.R. of 4.2. Although different ways can be proposed to increase the torque of the wind turbine, the following is proposed: to keep the angle of attack constant with a value equal to 10 throughout the revolution.

Even though this control strategy can present great practical drawbacks, since they involve an actuator that can rotate 360 º with a speed at least equal to the speed of rotation of the wind turbine, it allows to establish an analytical starting point that manages to weigh quantitatively that so much can be increased the torque produced with this theoretical and ideal strategy. To carry out such a test a modification was made to the algorithm to obtain these curves with a constant angle of attack but calculating the Reynolds number that depends on the local result of the wind speed in the blade in both the high-speed and low-speed areas.

The graphs in Figures 12 and 13 show the comparison of the wind turbine's behavior with a free and forced angle of attack to be constant and equal to 10º. It is evident that under this hypothetical test it is possible to increase the torque produced almost to four times.

Many other strategies can be proposed to increase the efficiency of the wind turbine, for example, one that works differently in the four quadrants of the angular position of the blades and whose control objective is: to move the angle of attack as far away as possible from the minimum value and bring it as close as possible to the maximum value.

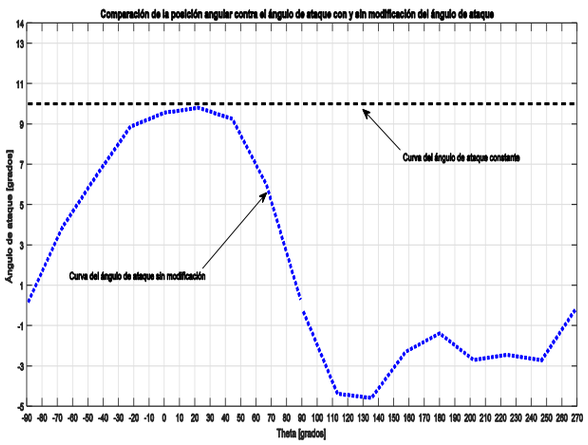

Figure 3 Plot of the angular position against the free and forced angle of attack
Own Elaboration whit MATLAB

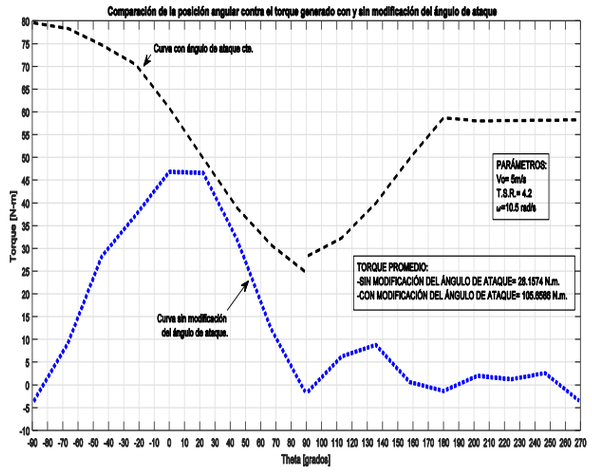

Figure 12 Comparison of average torque with free and forced angle of attack
Own Elaboration whit MATLAB

Transient response tests with two input signals

This group of tests seek to show, for the first time, the characteristics of the transient response of the wind turbine to two different test inputs, remembering that the input of the wind turbine is the wind speed. The two selected test inputs are: (i) step input (Figure 14) up and down (7), and (ii) sine wave (Figure 21) with a CD component (8).

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The first input signal seeks to simulate how the wind turbine responds from rest to a wind gust of 10 m /s with a duration of 4 minutes that then disappears, the second signal seeks to simulate a wind gust that increases and decreases around 6 m / s of speed in a periodic way.

$$u_1(t) = \begin{cases} 0.01 & t < 10 \\ 10 & t \geq 10 \\ -10 & t \geq 250 \end{cases} \quad (7)$$

$$u_2(t) = Asen(\omega t) + \varphi \quad (8)$$

With A=5, ω=0.062831 and φ=6. To obtain these dynamic responses, the positions, and angular velocities of each of the blades must also be established:

$$\theta_1 = \dot{\theta}_1 = \dot{\theta}_2 = 0 \quad (9)$$

$$\theta_2 = 180° \quad (10)$$

The responses with the input u_1 (Figures 14-15) show: (i) a variant torque with area under the positive curve (Figures 18 and 21), (ii) a transient ascent response with settlement time of approximately 35 seconds. (Figures 19 and 20), (iii) a periodic stationary response (Figures 19 and 21) and (iv) a transient descent of approximately 200 s. (Figs. 19 and 20). As can be seen there is a difference of almost 6 times the transitory of descent with respect to the one of rise. This can be explained because there is a singularity when the input velocity becomes null since the T.S.R becomes infinite. To minimize this effect the input is not made zero, but equal to 0.01 m/s, however, even with this small value the difference between up and down settlement time is noticeable.

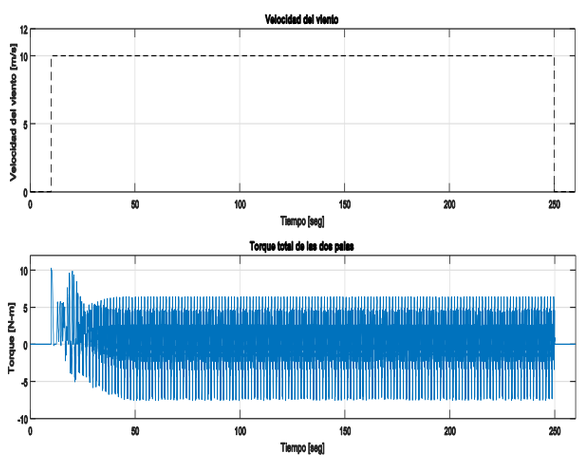

Figure 13 Graphs of wind speed u_1 and total torque
Own Elaboration whit MATLAB

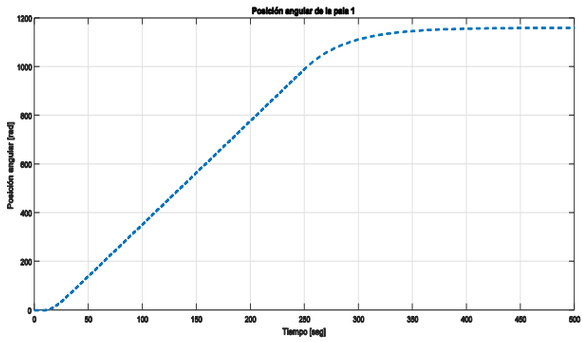

Figure 4 Angular position of blade 1 generated with input u_1
Own Elaboration whit MATLAB

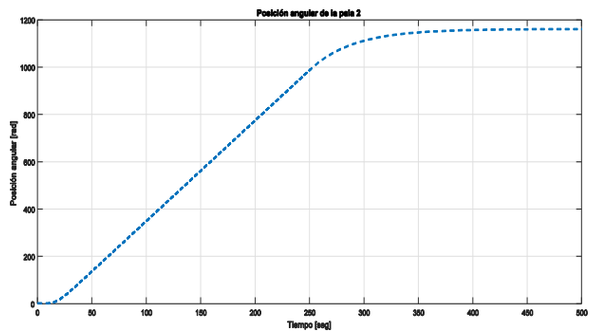

Figure 5 Angular position of blade 2 generated with input u_1
Own Elaboration whit MATLAB

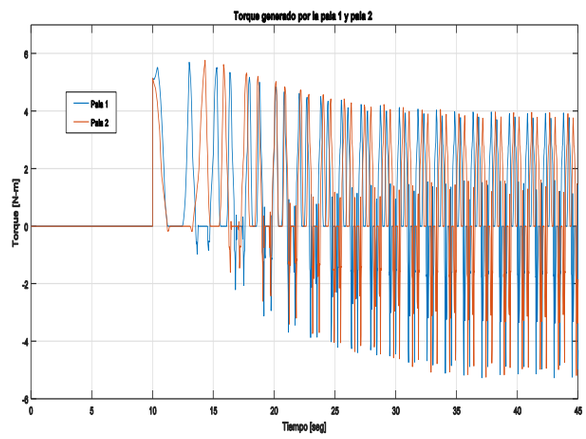

Figure 6 Comparison of the torque generated from blade 1 and 2 with input u_1
Own Elaboration whit MATLAB

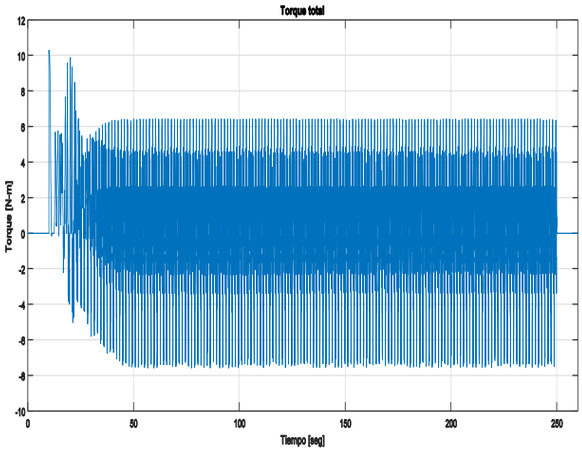

Figure 7 Total generated torque with input u_1. own elaboration whit MATLAB

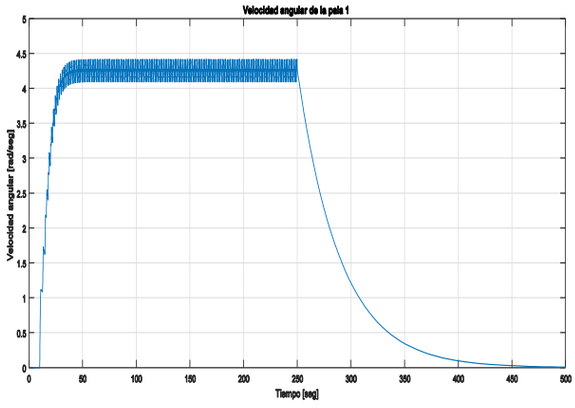

Figure 8 Angular velocity of blade 1 generated with input u_1
Own Elaboration whit MATLAB.

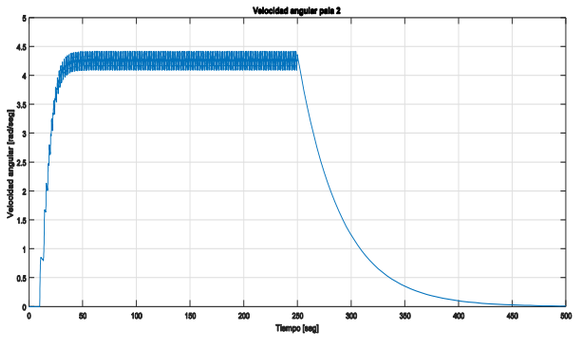

Figure 9 Angular velocity of blade 2 generated with input u_1
Own Elaboration whit MATLAB

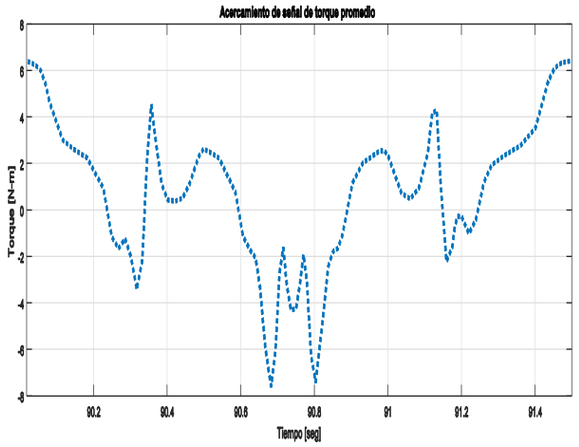

Figure 20 Approximation of the total torque in the standing state with the input u_1
Own Elaboration whit MATLAB

In Figure 18 showed the shape of the test 2 input, where it is clearly noted that the output maintains the oscillation period from its inputs and the quadratic relationship between wind speed and torque described with the help of the static model. This shows that the settlement time is inherent in the system and independent of the input. In the stationary state there is also an average torque with a positive part which explains the variation of the speed within a minimum range (of 0.75 rad/s) and maximum (of 5 rad/s) in the stationary state (Figures 10). The angular position varies in the period dictated by the input (Figures 23-24) as expected. Another very noticeable aspect is that the torques of blades 1 and 2 cancel out for certain time intervals; for example, for the interval of 12 to 17 seconds (Figure 25) which causes the angular velocity to decrease for each blade and therefore the torque generated.

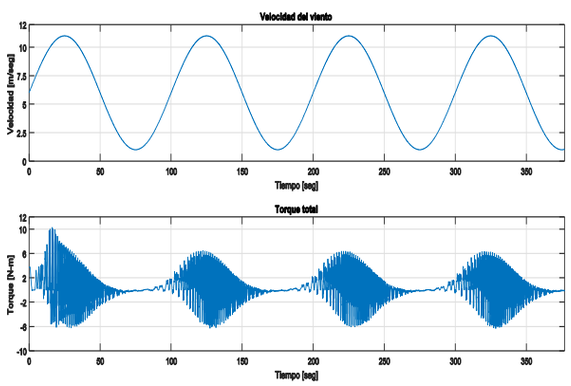

Figure 21 Velocity plots with input u_2
Own Elaboration whit MATLAB

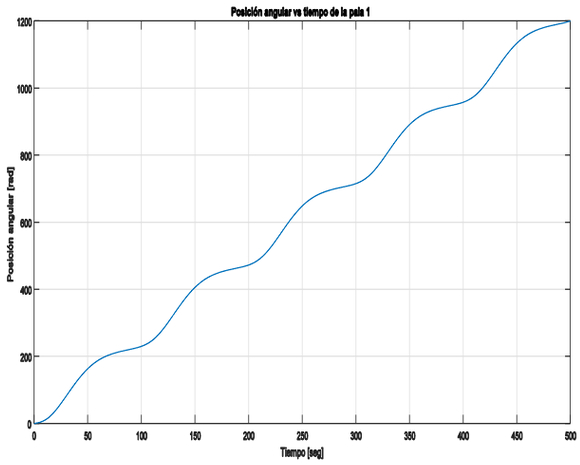

Figure 22 Angular position of blade 2 generated with input u_2
Own Elaboration whit MATLAB

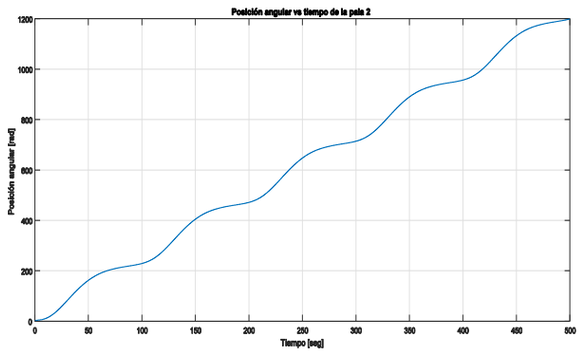

Figure 23 Angular position of blade 2 generated with input u_2

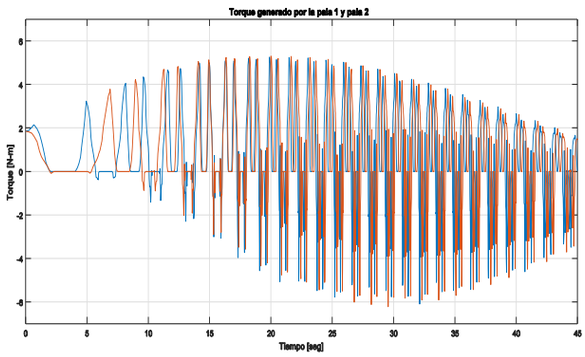

Figura 24 Comparación del torque generado de la pala 1 y 2 con la entrada u_2
Own Elaboration whit MATLAB

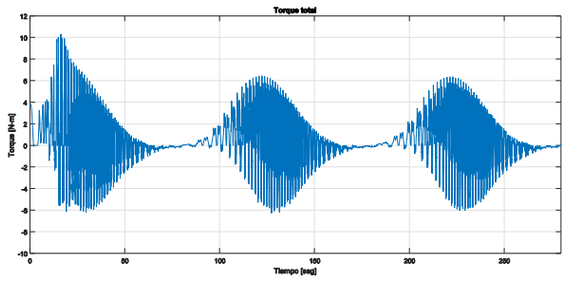

Figura 25 Torque generado total con la entrada u_2
Own Elaboration whit MATLAB

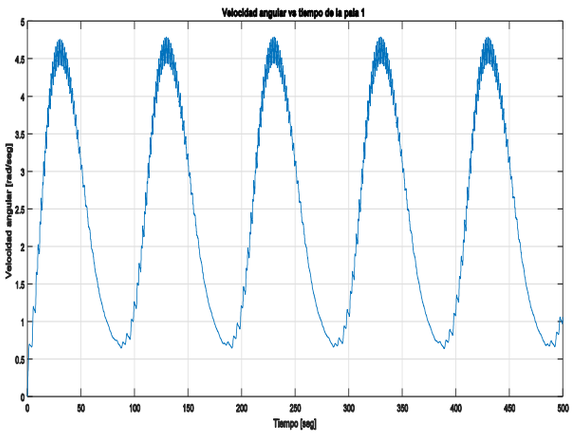

Figura 26 Velocidad angular de la pala 1 generada con la entrada u_2
Own Elaboration whit MATLAB

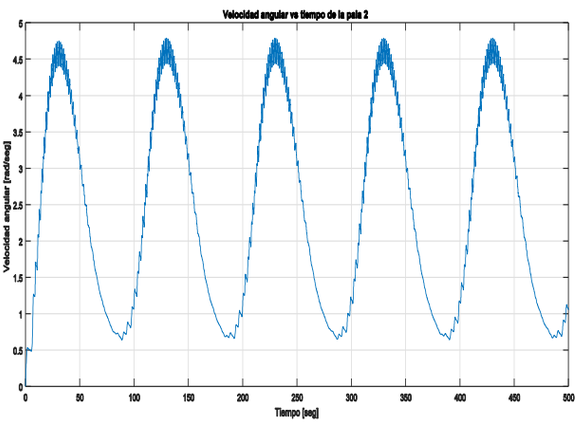

Figure 10 Angular velocity of blade 2 generated with input u_2
Own Elaboration whit MATLAB

3.2 Analysis of the graphs obtained with sinusoidal input

This analysis shows that as with step entry the system tends to enter its area in a stationary state in approximately 35 seconds (Figure 28). This gives us a better idea of the behavior that the wind turbine should have with this type of wave and these parameters.

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Regardless of this, the purpose of this test is to simulate by means of a sinusoidal input the behavior that the wind turbine would have before high and low levels of wind speed.

Based on the graphs (Figures 24 and 25) even though the input has high and low wind speed (Figure 23) the position of the blades continues to grow, in other words, the wind turbine continues to rotate. On the other hand, the angular velocity reaches a maximum of 5 rad/sec and a minimum of 0.75 rad/sec, this shows that, if indeed the wind turbine does not stop turning, it has high and low speeds, but the wind turbine continues to rotate.

In addition, total torque is proportional to wind speed (Figure 26). Another important aspect is that the torques of blades 1 and 2 are cancelled for certain time intervals such as for the interval of 12 to 17 seconds (Figure 25) what causes is that the angular velocity decreases for each blade and therefore the torque.

Comparison of stationary responses with static and dynamic models

To equate the two models proposed and implemented in this work on equal terms, this last test is proposed: the comparison of stationary responses with static and dynamic models. It should be noted that a perfect quantitative agreement is not expected to be found since the models differ in the number of tubes considered for the calculation of the parameters of the area of influence of the blades; while the dynamic model considers a single pipe segment, the static model considers 20.

The 26 shows a cycle of the stationary responses obtained with the static and dynamic models respectively, and Table 5 shows the maximum, minimum and average torques of each of the responses. It can be observed in the stationary values that there is a quantitative agreement in the three torques considered.

A great qualitative agreement can also be observed since the curves present very similar regions: (i) two areas with predominantly positive torque at the beginning and end of each cycle and (ii) an area with predominantly negative torque values in the middle part of the cycle.

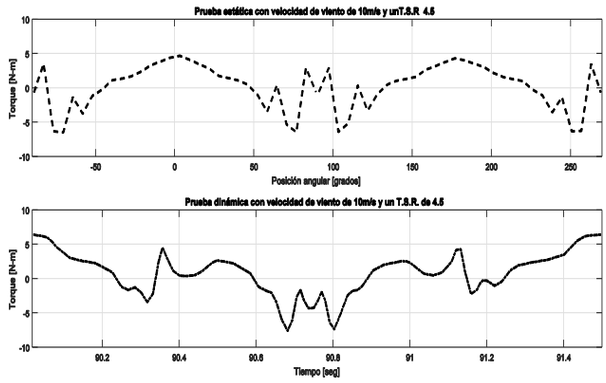

Figure 28 Comparison of torque in a stationary state cycle with static and dynamic models with a wind speed of 10m/s
Own Elaboration whit MATLAB

Model	Average torque	Maximum torque	Minimum torque
Static	1.0678 Nm	5.0 Nm	-7.0 Nm
Dynamic	1.2488 Nm	6.2 Nm	-7.5 Nm

Table 2 Comparison of the static and dynamic parameters of the static and dynamic models
Own Elaboration

Conclusions

The aim of the present research was to show the modeling, simulation, and analysis of the aerodynamic characteristics of the main components of a vertical axis wind turbine. It was reached by achieving the initial objective, which was to establish and implement in simulation two mathematical models of the vertical axis wind turbine to obtain the stationary and transient state responses.

The results from the analysis of the stationary and transient responses with both models allow to conclude that: (i) the torque generated is proportional to the square of the wind speed, (ii) there are attack angles where the generated torque is minimized and maximized, (iii) for a vertical axis wind turbine with two straight blades there are certain time intervals where there is an cancellation of the torques generated, (iv) the transient response is inherent to the physical parameters of the wind turbine and independent of the input and (v) for periodic signals, the output of the system retains the oscillation frequency given by the input.

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Alternatively, simulations were only made with a vertical axis wind turbine with two blades, being that the software designed can be easily modified to consider a greater number of blades. In addition to the fact that it is possible to modify it suitably for the inclusion of a straight blade wind turbine with central plunger.

Other aspects to improve the algorithms are: (i) the inclusion of the model with multiple current tubes in the dynamic model, (ii) the inclusion of the pitch angle directly in the numerical calculations of the simulation, (iii) the analysis of the number of tubes sufficient for a correct decrease of the error in the numerical approximation and (iv) the inclusion of a greater number of points in the table of angle of attack and number of Reynolds for the calculation of the coefficients of lift and drag to improve the accuracy of the numerical calculations of the algorithm

Acknowledgements

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College student learning styles and interests in times of pandemic

Estilos de aprendizaje e intereses de los estudiantes universitarios en tiempos de pandemia

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Abstract

Learning styles are different methods that students use to learn, influenced by different factors that modify this learning, such as motivation, study methods, and the student's attitude, among others. This work focuses on the learning styles and interests of the university student, the main objective is to identify the factors that affect the learning style and interests of higher education students in times of pandemic. The methodology was integrated from the research instrument that generated information for the explanation of this issue, its focus being quantitative, in addition to the theoretical value based on the integration of theories. The research was carried out with a sample of 1,412 higher education students. The instrument was designed considering 160 variables, 10 signal variables and 150 variables of learning styles and interests divided into several subdimensions, the STATISTIC program was used for statistical treatments based on frequencies, percentages, comparison and factorial analysis. Among the main research results it was found that women attend college because they have an interest in learning and preparing to successfully achieve their goals, and not just because of a college degree, unlike men. In addition, students are clear that experience is essential to develop the knowledge acquired, having a real experience of what the world of work is, venturing into them and at the same time being learning. The intervention proposal is to promote in the universities that from the first semesters or semesters the student is allowed to have a real experience in the labor field about his career.

Interest, Learning Styles

Resumen

Los estilos de aprendizaje son diferentes métodos que utilizan los estudiantes para poder aprender, en los cuales influyen diferentes factores que modifican este aprendizaje como la motivación, los métodos de estudio, la actitud del alumno, entre otros. El presente trabajo tiene como ejes los estilos de aprendizaje y los intereses del estudiante universitario, el objetivo principal es identificar los factores que inciden en el estilo de aprendizaje y los intereses de los estudiantes de educación superior en tiempos de pandemia. La metodología se integró a partir del instrumento de investigación que generaba información para la explicación de este tema, siendo su enfoque de corte cuantitativo, además que el valor teórico radico en la integración de teorías. La investigación se realizó con una muestra de 1412 estudiantes de educación superior. El instrumento se diseñó contemplando 160 variables, 10 variables signalíticas y 150 variables de los estilos de aprendizaje e intereses dividido en varios subdimensiones, se utilizó el programa STATISTIC para los tratamientos estadísticos a partir de frecuencias, porcentajes, comparación y análisis factorial. Entre los principales resultados de investigación se encontró que las mujeres asisten a la universidad porque tienen interés en aprender y prepararse para lograr sus metas con éxito, y no solo por obtener un título universitario, a diferencia de los hombres. Además, los estudiantes tienen en claro que la experiencia es fundamental para desarrollar los conocimientos adquiridos, teniendo una experiencia real de lo que es el mundo laboral, aventurándose en ellas y al mismo tiempo estar aprendiendo. La propuesta de intervención es promover en las universidades que desde los primeros semestres o cuatrimestres se le permita al estudiante tener una experiencia real en el campo laboral sobre su carrera.

Interés, Estilos de Aprendizaje

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Introduction

Since ancient times, the human being began his learning process spontaneously and naturally with the purpose of adapting to his environment, in this way he has been surviving the different changes that have occurred in the world. Learning styles are all those cognitive and physiological traits by which students perceive and interact within the learning processes That is why the present research aims to make known the learning strategies and interests that move the university student in these times of pandemic that he is living.

Justification

This research is important in consideration of the explanation that will be obtained about how the learning styles and interest of the university student intervene in their academic performance Students from the different universities in Mexico will be the main beneficiaries; in consideration that teachers will be able to distinguish how it affects the learning styles and interests of the university student to implement strategies that impact their academic performance in times of pandemic.

The theoretical value of this research lies in the integration of bibliographies referring to the subject and the instrument. On the other hand, the methodological value is integrated from the research instrument that will generate information to explain these phenomena. The viability of this project lies in the fact that the research contents respond to needs that impact society and the educational environment every day.

General objective

Identify the variables that make up the learning styles and interests of higher education students in times of pandemic.

Research questions

- How often is the male gender in the sample?
- What percentage of students is 21 years old?
- What is the comparison that exists between the students who study by semester and semester with respect to the manual of impressions?
- What are the variables that make up the study method?
- What are the variables that make up the printing manual?

Theoretical framework

Learning styles

Learning styles are all those cognitive and physiological traits by which students perceive and interact within the learning processes. However, this concept has evolved over time.

Jester, (2000), defines learning styles as "the way that students prefer to learn and that have nothing to do with intelligence, but with the way the brain works more efficiently to learn new information."

Later, (Cazau, 2004) defines the term Learning Style "to the fact that each person uses their own method or strategies to learn. Although the strategies vary according to what one wants to learn, each one tends to develop preferences or global tendencies that define a Learning Style. There is talk of a general trend, since, for example, someone who is almost always auditory can in certain cases use visual strategies".

However, 5 years later the learning style was established as a set of biological and maturation ally-imposed characteristics that make the same teaching method effective for some learning styles, which is like a personal stamp. Learning styles are determined by the biological characteristics of each person and by the estimate received, (Plan PROA, 2009).

Gallego, (2010), mentioned that learning styles are defined as cognitive, affective and physiological traits that serve as relatively stable indicators of how individuals perceive, interact and respond to their learning environments Therefore, conceptually learning styles they are understood as personal variables that, halfway between intelligence and personality, explain the different ways of approaching, planning and responding to the demands of learning. Learning styles have become elements of great importance to promote quality teaching. (Tapias, 2018) mentioned that Learning Styles are cognitive, affective and physiological traits that serve as relatively stable indicators of how students perceive, interact and respond to their learning environments.

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The Learning Styles construct arises with the purpose of jointly examining the cognitive and personality aspects that participate in all learning situations (Sternberg cited by Fernández, 2020). According to Keefe, Learning Styles are defined as the cognitive, affective and physiological qualities that students put into play when learning (Keefe cited by Freiberg-Hoffmann, 2020)

Finally, (Pérez, 2021) refers to the fact that a learning style consists of a series of personal characteristics with which you are born and that you develop as you grow up. Determine, among other things, through which activities and senses you tend to absorb information more easily; whether through sight, sound, touch, speech, note-taking, or a combination of these. There are three major systems to mentally represent information, the visual representation system, the auditory and the kinesthetic. Most of us use one more than the other, because they develop differently in each one of us and have their own characteristics.

The visual representation system tends to be the dominant representation system in most people. It occurs when one tends to think in images and relate them to ideas and concepts. The people who are information by following and recalling an oral explanation. And Kinesthetic Representation System is about learning related to our sensations and movements. In other words, it is what happens when we learn more easily by moving and touching things, such as when we walk when reciting information or doing an experiment manipulating laboratory instruments.

1.2 Learning styles in times of pandemic

In recent years, where the entire world situation has been affected by the pandemic related to COVID 19, various studies have been carried out that seek to investigate the factors that impact the learning styles and interests of the student, in that sense for Trucco and Palma (2020) the massification of connectivity based on the mobile Internet and the increase in more accessible digital devices, policies have redirected their efforts to the formation of digital skills of students.

For many women and girls, confinement means an exacerbation of the unpaid care workload, which in turn has consequences for their learning. According to the International Labor Organization (ILO, 2018) For Miguel Román, J. A. (2020) in a study carried out concludes that:

"Teachers are in a state of learning and rupture, as are students; Both actors warn that it is necessary to develop self-learning, autonomy and socio-emotional skills. In sum, it is essential to rethink that the roles of each of the actors in the training process in higher education require a paradigm shift; transform our limitations into strengths and appropriate each of our responsibilities. Today more than ever, in times of pandemic, education must take a complex approach, since the totality often exceeds the sum of its parts. It is therefore necessary to educate for uncertainty"

Likewise, for Enríquez Vázquez Larisa and Hernández Gutiérrez Myrna (2020) in relation to learning, they consider that the participation that the teacher should have in, in addition to the traditional cognitive dimension, the metacognitive, social, and action-oriented dimensions is clear. . But, above all, in the context generated by covid-19, in the affective-emotional dimension, since the current emergency shows the need for accompaniment and listening.

1.2 Learning styles in relation to academic performance

Most researchers agree that academic performance is the result of learning produced by the didactic and pedagogical interaction of the teacher and student. For (Pizarro, 1985), academic performance is "a measure of the responding or indicative capacities that express, in an estimate, what a person has learned as a consequence of a process of instruction or training"; while (Martínez & Otero, 2007) considers that academic performance is "the product that students give in schools and that is usually expressed through school grades". (García, 2018) It determined that learning styles are a factor that significantly influences the academic performance of students; But you can't just blame learning styles; On the contrary, there is a diversity of factors that influence academic performance, among them are: socioeconomic, teaching methodologies, previous competences, motivation.

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It is clear that the students' preferred style is the reflective one characterized by being investigative, analytical, working assertively and as a team, managing to understand the data analyzed in a systemic way, leading them to solve various problems by applying the knowledge learned in an integrative way.

Estela (2021) in an investigation carried out in which I compare the learning styles in students of the civil engineering and agroindustry engineering career of a University of the city of Chota, Cajamarca; During the course of the year 2021, he found that the results showed that in general there are no significant differences regarding learning styles according to gender in this context.

García, (2017) mentions that the relationship that exists between the Learning Styles and the Academic Performance of the students of the courses of the construction area of the FIC-UNI, 2017, was tested with the statistical inference that there is no relationship between the Learning Styles and Academic Performance of the students under study, in the academic year, 2017.

Gallo, (2018) determined the relationship between Learning Styles and Academic Performance of Economic Engineering students from a public university. It was a quantitative investigation, at a descriptive level, with a non-experimental cross-sectional design. The population was 470 and the sample of 92 students enrolled in the 2017-1 cycle. The CHAEA questionnaire was used, which consists of 80 items. It was found with the descriptive and inferential statistics that there is no significant correlation between the theoretical learning style and the academic performance with p value = 0.384. There was also no significant relationship between the reflective style (p = 0.371), pragmatic (p = 0.438) and active style (rp = -0.002) since the significance was greater than 0.05 in all cases.

Clump and Skogsberg (2003) point out that during the development of the ILP (Inventory of Learning Processes), Schmeck et al. (1977) found no significant differences in learning styles between men and women.

ILP-R Instrument

The Learning Process Inventory Id. The first measure of learning styles that had been developed in the context of cognitive psychology and derived from information processing theories. The objective of this article is to determine the validity of the Spanish adaptation of this questionnaire. Almost 30 years have endorsed this instrument since the appearance of the first version in the United States. The ILP was constructed from factor analysis applied to a survey of a sample of students on studies describing activities and assumptions based on cognitive psychology, such as memory and information processing. Factor analysis uncovered four factors called deep processing, elaborative processing, data retention, and study method.

Ruiz, Fuensanta Cerezo, & Manuel Esteban, (1996), mention that both deep and elaborative processing refer to learning strategies that require reflection. Although they differ in the personal way of facing the task of learning: Deep processing is more abstract, logical and theoretical, it is what we could call "academic style", while elaborative processing is more experimental and self-expressive. Data Retention is geared toward the retention of units of information necessary to successfully perform multiple-choice tests.

The Study Method is composed of those skills that are usually applied when studying a topic, such as the use of a library or dictionary, underlining, collecting notes, ordering notes, etc. Studies on the validation of the questionnaire showed significant correlations between learning strategies and personality variables. For example, Schmeck and Ribich (1978) found that individuals who scored high in deep processing (abstract and theoretical) were able to use conformist or independent thinking depending on the situation, while those who did so in data retention and method. of study tended to act only by the conformist route. Similar relationships were found between information processing styles and personality, especially with Self-efficacy, Self-esteem, Self-affirmation, Locus of control, Anxiety and Fear of failure. In several cases, the personality variables acted as mediators of the control of anxiety and fear of failure. In other cases, the personality variables acted as information processing and the current performance variables.

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Thus, for example, Schmeck and Spofford (1982) found that moderate neuroticism correlated with the tendency to use deep processing and that a moderate degree of fear of failure correlated with paying more attention to superficial aspects of the information. In 1988, Schmeck added two new dimensions of effectiveness: thinking and memorization and two others on cognitive style: serial and holistic. Despite these variations, certain consistencies emerge in all applied versions.

Personality and cognitive process items are grouped consistently, which means two ways of producing a hierarchical model of individual differences in behavior and attitudes for learning: academic self-efficacy, self-esteem, self-assertion and motivation appear as dimensions. not cognitive or personality. Deep processing, elaborative, impulsive and the study method appear as cognitive or learning dimensions. (Manuel Esteban, Cecilia Ruiz, & Fuensanta Cerezo, 1996)

The questionnaire contains the aspects of the phenomenon that are considered essential; It also allows us to isolate certain problems that interest us mainly; reduces reality to a certain number of essential data and specifies the object of study.

Methodology to be developed

When the primary research question is established, one begins to inquire about the bibliography that supports the primary initiative of this work, the goals, questions of inquiry and inquiry conjecture are developed, which are consistent with the primary and complicated changes of the instrument to use.

It should be noted that a standardized tool from Spain was used and certain expressions were adapted that have the possibility of causing confusion in the subjects to whom the survey was applied, this in order to avoid biases. The measurement of the sample was concluded based on pre-established criteria that indicated the need to exercise the instrument on 1412 people, with which the instrument was adapted to a digital version given the social conditions in which this work is carried out.

In such a way that the application has been made through a Google form, which allowed to skip the data capture to go directly to its procedure. The instrument consists of 2 sections: the first contains the general data where changes are observed: Age, Gender, Location where they study, Type of studies, currently working, Average, has worked, University where they carry out their studies. The third section corresponds to the magnitudes of Learning styles and various interests of them with subdimensions that are made up of 150 items that are measured on a scale from 1 to 6.

Once organized in a concentration matrix, the data obtained are given statistical treatment to explore the results where a Cronbach's alpha of 0.91 is received. In addition, the information is processed through descriptive statistical studies (frequencies and percentages), comparative (Student's t test for independent teams) and with the Integrational (with exploratory factorial research); It is a quantitative, synchronous and transversal investigation of an exploratory and detailed type.

Result

1. Descriptive Analysis

1.1 Frequencies and Percentages

To analyze the values of the signal variables that represent the sample studied, an analysis of frequencies and percentages applied to the subjects under study is carried out, the total of which corresponds to a value n of 1412.

In the analysis of the gender variable, results were obtained where it is observed that 64.38% of the population corresponds to the female gender, while 35.06% corresponds to the male gender.

Analysis of frequency and percentage of the gender variable			
	F	**Fa**	**%**
Male	495	495	35.06
Female	909	1404	64.38
Female/Male	8	1412	0.57
Note: f = frequency, fa = cumulative frequency, % = percentage,			

Table 1 Analysis of frequency and percentage of the gender variable
Source: Own Elaboration

Where their age range is from 14 to 52 years, their average being 22 years with 13.17%. In addition, 78.61% (n = 1110) of the studied population carried out their studies in the city of Saltillo.

In the results obtained in the variable university career, with a total of 179 majors it is shown that the most outstanding are Lic. In psychology with 11.69% (n = 165), Lic. In educational sciences with a percentage of 11.40% (n = 161) and Industrial Engineering with a percentage of 8% (n = 113).

2. Comparative Analysis

2.1 Student's t for independent samples

Next, a comparative analysis of the variables that make up the phenomenon of study is presented, carried out through the Student's t test procedure for independent samples, with a confidence level of 95%. The statistical program STATISTICA was used to analyze the significant differences between gender, age, state where they study, city where they study, educational institution, career, modality, average, current job and previous job; which were contrasted against the dimensions of the investigation.

A study of means is carried out through the Student's t test for independent samples, defining the working hypothesis H1 = "there are significant differences between the comparison groups". The results of interest for the work are those in which the Student's t test indicates the existence of significant differences between the comparison groups.

The results of interest for the work are those in which the Student's t test indicates the existence of significant differences between the comparison groups. The readings and inferences corresponding to the different comparative analyzes that are of interest to the study are presented below. It can be observed that, according to comparison analysis of the means of the variables, women have greater enthusiasm for learning, prepare for exams and carry out their tasks appropriately, always seeking success in what they do, knowing that the only way to meet your goals is by taking an interest in their learning, unlike men.

Thus, it is inferred that women attend college because they have an interest in learning and preparing to achieve their goals successfully, and not just because of a college degree, unlike men.

According to the comparative analysis of the means of the variables, it is observed that women use different techniques, such as diagrams, summaries, and notes, so that their learning is better, and they investigate on their own questions that they do not understand the first time. It is inferred that women look for a way that their learning is of better quality through didactic supports where they express their ideas, unlike men. Likewise, it is observed, according to the comparative analysis, that women pay more attention in class, however, they forget the things they learn faster than men. From the above, it can be inferred that, although men pay less attention in class, they are less likely to forget what they learn than women.

It was found that students who are 21 years old like to read articles that have to do with their studies to obtain more knowledge and, in addition, they reflect on what they have learned in class to successfully elaborate their tasks, unlike those who are 23 years old. Among the variables that measure the study method, there are significant differences between the ages of 21 and 23 in the following: Students who are 21 years of age strive to get good grades in their exams, relying on diagrams made on material from class, unlike 23-year-old students.

Therefore, it is inferred that students with the age of 23 do not worry so much about studying to get good grades in their exams, since they remember much of the content seen, unlike students with 21 years. Students who have a 93 average is because they are interested in their personal training and attend university for the pleasure and desire to learn, in addition to having clear goals and maintaining a positive attitude unlike students who have a 75 average. Based on the above, it is inferred that students who have a 75 average is because it is difficult for them to study and they prefer to spend more time with friends than studying, unlike students who have a 95 average.

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3. Integrational Analysis

3.1 Exploratory factorial

With the intention of affirming that there are factors that describe the learning strategies and appropriation of knowledge present in higher-level students from the elements that make up their learning styles and interests, an exploratory factorial analysis was carried out, in which it was considered the Kaiser criterion. As an extraction method, the Maximum Likehood was used; with normalized Varimax rotation as it is It is integrated with variables that support the paradigm proposal. We work with an error level $p \leq 0.001$ and a confidence level of 95 % and a value $r = 0.33$.

The study shows the existence of 12 factors, which 44% explain the objective reality of the phenomenon under study. Next, six factors will be read, according to the sedimentation graph where the inflection point of the dimensions of global motivation, study method and manual of impressions is presented. The first factor was named personal interest. In the factor, it is observed that students who are within said factor stand out for having self-efficacy because they think quickly and without making mistakes, since, in most of their exams they obtain the correct answers, in addition, they have the ability to remember small details that are of great importance to them when studying.

They are motivated by wanting to improve themselves personally, therefore, they attend university for their own pleasure, always having an enthusiastic attitude and taking the fun side of learning, performing their tasks correctly and with determination to be able to achieve their established goals, doing it with pleasure and to be as successful as possible in their lives. Likewise, they are students with an outgoing personality, who are not afraid of being criticized by other people, always expressing their ideas, and contradicting other people's opinions when something does not seem to them. The study method used by these students are techniques and strategies of summarizing information, making it more concrete and accurate, making diagrams and graphs as study support when studying for their exams, investigating the material seen in class and when something does not show them. It is clear they investigate on their own until discovering the meaning, therefore, their vocabulary is increasingly enriched with new words, in addition, they raise their ideas and order them to be clear about the learning.

They are students who when a problem is presented to them always look for their solution, using all the alternatives that are within their reach, looking for scientific explanations, comparing theories for a better resolution and relating ideas, in addition, they are supportive students than when someone else has some problem and is having difficulty solving it, offer your help without expecting anything in return.

They are clear that experience is essential to develop the knowledge acquired, having a real experience of what the world of work is, venturing into them and at the same time being learning without forgetting the values that the family instills to always be an honest person. Likewise, they have their system to remember learning or situations that serve them, associating subject words.

They have a very good imagination, they are intuitive, when they have an idea in mind they tend to involve external ideas in order to relate them, relying on images that help them to better manage and clarify points of view. They always use reason and logic to solve their doubts and problems, attending to complicated situations through steps, so that everything goes in order and as expected.

They are rote students, where they tend to repeat and repeat everything seen in class to have a better acquisition of knowledge, always relying on their teacher as a guide. In factor 2 named Disinterest, it can be said that students who are within this factor stand out for having difficulty in their learning, since, they do not organize themselves to carry out their activities, they have problems remembering topics seen, they tend to get confused, they are Nervous people are easily distracted, and do not have the ability to relate ideas and solve problems, therefore, they have difficulty studying in their exams.

They do not know how to make a critical evaluation, or differentiate between logical aspects. They are students with poor memory, and for the same reason they get bored easily in classes and settle only for what they come to understand without inquiring on their own, they are irresponsible since they are not interested in studying to get good grades on their exams. They have low self-esteem, as they are affected when people criticize them and they get nervous when they do.

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They need professional guidance. In factor 3, named Efficient memory, it is said that students who are within this factor are dependent, do not have their own decisions and always have to help them choose other people, as well as they believe that success is a matter of luck. However, they are organized students who distribute their activities in schedules so that everything goes as it should, they are learning by rote, since they have a perfect memory and remember any data that has been presented to them. They are responsible people who always study for their exams, do their homework, and are attentive in class.

In factor 9, named Irresponsibility, it is said that the students who are within this factor are people who do not use the library or the dictionary so much, they do not like to read or reflect on what they read, they are in university just to get a professional title without caring what they can learn, they do not intend to apply the knowledge they acquire, they are dependent people, they have to be told what to do and how to do things so as not to have complications, and they like to go out with friends more than study for their exams.

In factor 10, named Learning strategies, it is read that students within this factor use different study methods for the presentation of their exams, they make use of a list of questions and answers that possibly come within the exam, they repeatedly read the They viewed content, they make summaries, diagrams and graphics of the material worked on in class, they organize themselves in their schedules and they repeatedly review their notes relating them to their ideas.

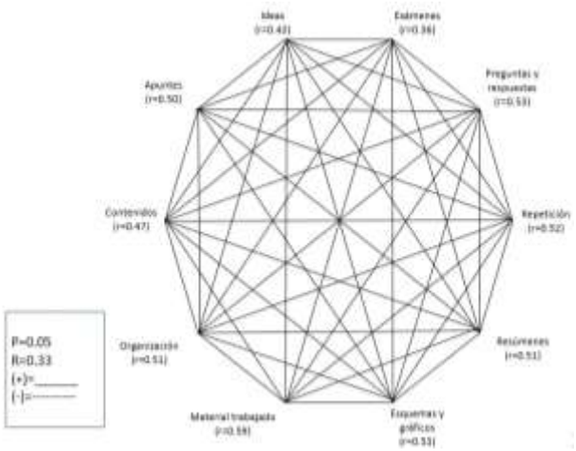

Figure 1 Exploratory factor analysis, Factor 10. Person imagel

In factor 11, named Interest in learning, it is observed that students who are within this factor go to university because they are interested in learning new and interesting things, in addition, they are clear about their goals knowing that they can be successful academically. They have a positive attitude, always willing to learn and carry out the activities assigned to them.

Conclusions

Women attend college because they have an interest in learning and preparing to achieve their goals successfully, and not just because of a college degree, unlike men.

Women look for the way that their learning is of better quality through didactic supports where they express their ideas, unlike men.

Although men pay less attention in class, they are less likely to forget what they learn than women.

21-year-olds have a greater interest in reading and reflection, and are more responsible for their homework unlike 23-year-old students.

23-year-old students do not worry as much about studying to get good grades on their exams, since they remember much of the content seen, unlike 21-year-old students.

The students who pursue their career in the city of Saltillo are not interested or clear about their goals, so they do not enjoy their learning, unlike students in the city of Monterrey.

Students who have a 75 average is because it is difficult for them to study and they prefer to spend more time with friends than studying, as opposed to students who have a 95 average.

Students of personal interest are motivated by wanting to improve themselves, therefore, they attend university for their own pleasure, always having an enthusiastic attitude and taking the fun side of learning, performing their tasks correctly and with determination to be able to achieve their established goals.

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Students who have disinterest are noted for having difficulty in their learning, since, they do not organize themselves to carry out their activities, they have problems remembering topics seen, they tend to get confused, they are nervous people, they lose concentration easily, and they do not have the ability to relate ideas and problem solving, so they have difficulty studying on exams.

Students with effective memory are organized who distribute their activities in schedules so that everything goes as it should, they are rote learning, since they have a perfect memory and remember any data that has been presented to them.

Students who are irresponsible are people who do not use the library or the dictionary so much, they do not like to read or reflect on what they read, they are in university just to obtain a professional degree without caring what they can learn, they do not pretend to apply knowledge They acquire, they are dependent people, they have to be told what to do and how to do things so as not to have complications, and they like to go out with friends more than study for their exams.

Students who use learning strategies use different study methods for the presentation of their exams, make use of a list of questions and answers that may come within the exam, repeatedly read the contents seen, make summaries, diagrams and graphics of the material studied in class, they organize their schedules and repeatedly review their notes relating them to their ideas.

Students who are interested in learning at university because they have an interest in learning new and interesting things, in addition, they are clear about their goals knowing that they can be successful academically.

Discussion

In the results it was found that students use didactic methods such as diagrams, graphs, summaries, notes and repetition of words, involving their ideas and comparing them with others to have a better learning, for which they agree with the (Raco D-Study, 2020) where it says that a learning style is the way in which students respond to or use stimuli in the learning environment, that is, the educational conditions under which a student is more likely to learn.

As mentioned, in the results it was found that most of the students have different ways of learning, some use didactic methods, others memorization, others when viewing images, therefore, we agree with the author, (Pérez, 2021) that he mentions through activities and senses we tend to absorb information more easily; whether through sight, sound, touch, speech, note-taking, or a combination of these.

Proposals

Implement in universities that students have the opportunity to have work experience from the first semesters or semesters so that they can become familiar with real experiences.

Train teachers periodically so that they have the tools and knowledge necessary to teach their students with the various forms of teaching, this in order for each of the students to acquire knowledge in their own way.

Implement workshops where students express their ideas and learn to relate them to external ideas for greater learning.

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Virtual laboratories, an educational resource as a strategy for quality education

Los laboratorios virtuales, un recurso educativo como estrategia para una educación de calidad

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Abstract

Virtual laboratories are considered the simulation of a real laboratory, where the behavior of a certain is studied using mathematical models, and although it does not interact physically with the processes or systems, experimentation with simulated models it is comparable to reality. The objective is to recognize the benefits that virtual laboratories offer the student, as a tool in problem solving, linking theory with practice, and developing teamwork, all within distance learning. Therefore, a compilation of different sources of information regarding virtual laboratories was made, where it is stated that the interviewees who make use of this tool for their learning obtained a favorable response by identifying that they develop skills that prepare them for their experimental participation in a future. Therefore, it is considered a strategy for quality teaching.

Virtual Laboratory, Educational resource, Quality teaching

Resumen

Los laboratorios virtuales se consideran la simulación de un laboratorio real, en donde se estudia el comportamiento de un determinado sistema haciendo uso de modelos matemáticos, y aunque no se interactúa de forma física con los procesos y/o sistemas, la experimentación con modelos simulados es comparable con la realidad. El objetivo del presente estudio es reconocer los beneficios que los laboratorios virtuales ofrecen al estudiante, como herramienta en la resolución de problemas, la vinculación de la teoría con la práctica y el desarrollo del trabajo en equipo, dentro de la enseñanza a distancia. Se realizó una recopilación de diferentes fuentes de información referente a los laboratorios virtuales en donde se reconoce que quienes hacen uso de dicha herramienta para su aprendizaje obtuvieron una respuesta favorable al identificar que desarrollan habilidadespara el desarrollo y participación experimental a futuro. Por lo tanto, se considera como estrategia fundamental para una enseñanza de calidad.

Laboratorio virtual, Recurso educativo, Enseñanza de calidad

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Introduction

Currently, the teaching-learning process faces new challenges and areas of opportunity that must be assumed from the guidelines and principles of operation that govern educational institutions. At the same time, the role assumed by the teacher is of utmost importance, since through adequate training in the use of technology, the necessary skills can be developed so that what at first seems complicated becomes an enriching experience for both the teacher and the student. It must be recognized that strategies must be implemented so that the student is able to make decisions, so it is necessary to generate resources to achieve not only significant learning, it must also be effective, ethical and with great responsibility.

Virtual laboratories, which by the potential it develops in students, should be considered a priority to enable institutions to achieve an experimental participation to understand the theoretical knowledge but especially to relate these basic theoretical principles with the practical part of the topics studied within the subjects. Performing all scheduled practices in a timely manner within an institution is sometimes complicated by the time pressure, because there may be restrictions on the use of resources or simply because it is not a safe activity for the student, so using virtual laboratories makes possible the simulation of something that perhaps in other circumstances could not be carried out. Therefore, through the compilation of information, the benefits of using laboratories to obtain quality teaching are presented.

Background

Virtual laboratories began to be developed in 1997 at the Academic Research Center of the State Distance University of Costa Rica. Judging from the information available on the Internet, they were among the first virtual laboratories for distance learning worldwide. Four years later, there was a similar commercial project, the Virtual Frog Dissection Kit 1.0. (http://www.cs.ubc.ca/nest/magic/projects/hands/home, February 2000) and three academics: Diffusion Processes Virtual Laboratory (Johns Hopkins University.

There were also two virtual reality level projects, requiring VR headsets, in the United States and Canada. (NASA Virtual Reality Virtual Object Manipulation, www.nasa.gov y Virtual Hand. Virtual laboratories were originally developed within space and military programs with huge budgets. (Monge Nájera, 1998, Dormido et al. 2000, Gil et al. 2003), over the years became the option for those who suffer from the opposite: small budgets. An extreme case is that of Cuba, where students must work in real laboratories that are obsolete and lack maintenance and Internet access, according to Alejandro (2004). In the case of Europe, which decided to implement virtual laboratories in a very different context, it is often not a matter of dealing with problems of inadequate laboratories or access difficulties, but of protecting students from hazards associated with chemicals or mechanical devices, while protecting equipment from damage due to carelessness during the learning process. (Salzmann y otros, 1999; Candelas et al. 2003, 2004a, b).

Although the use of virtual laboratories was not considered very frequent, however, there is research about it that has been done, in this research some will be cited to learn more about it.

Monge Nájera y Méndez Estrada (2007) evaluated the virtual laboratories used by the students of distance education sciences at the UNED of Costa Rica, during six years, they studied through surveys the level of satisfaction in each course to the users of 12 virtual laboratories and in the results they obtained they affirm that the ease of use of the virtual laboratories is "good or excellent", it is pleasant to execute them and the illustrations and other graphic aspects are good.

On the other hand, Infante Jiménez (2014) points out those virtual laboratories are a valuable digital tool that effectively complements laboratory practice, with the advantages of being always available and accessible. The use of the virtual laboratory tends to rationalize the use of resources, decrease the negative impact on the environment and minimize the risks associated with occupational health.

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Likewise, Morales Castro et al. (2015) share that virtual laboratories are a support and complementary tool for the teacher, allowing him to innovate in traditional teaching, it is important to note that they do not replace real laboratories. Among its advantages, it is possible to repeat the practice at the request of the students in a reasonable time without affecting any other programming of a laboratory, contributing to the formation of professionals with quality and skills according to their profile of graduation, in addition, students use current technological tools and the incorrect use of physical equipment is reduced.

Vergara Rodríguez (2019) analyzed the opinion of students in relation to technological applications, and the positive experiences that are being lived in practical teaching by using virtual laboratories (LV) that reflect a number of clear advantages over traditional practical classes in real laboratories, the imposition of the LV in the educational sector is an unstoppable fact.

It is of vital importance that nowadays the continuity of the classes in a non face-to-face way does not affect especially the students who have to take subjects that require a fundamental experimental part. It is necessary to be aware that today's young people require a broad knowledge by linking theory with practice. Therefore, it is recognized that the lack of preparation of many university graduates to solve the problems they face in their first areas of professional practice, which translates into difficulty in entering the field (Morandi 1997). Based on the above, it is possible to highlight "know-how", that is, practical knowledge (Bourdieu 1991).

This problem could be considered as one of the main causes for the lack of interest in learning and dropping out of school. As stated by (Crissman and Upcraft 2005), the highest percentage of dropouts is concentrated in the first years, which is affirmed by the following: Teachers' commitment is essential and relevant when it comes to diminishing, and in the best of cases avoiding, such an outcome (Siegel 2005).

Virtual laboratories and their similarity to reality

In the field of computer science, the term virtual means "not real". In general, it distinguishes something that is purely conceptual from something that is physically real.

Such a distinction can be used in a wide variety of situations. This defines a virtual laboratory as a computer simulation of a wide variety of situations in an interactive environment; that is, the behavior of a given system to be studied can be simulated using mathematical models, and although there is no interaction with real processes or systems, experimentation with simulated models is comparable to reality, provided that such models are realistic and represent important details of the system to be analyzed, and that the graphs representing the temporal evolution of the system are complemented with animations that make it possible to see and better understand the behavior of the process.

Generally, a digital laboratory manual is available, in the same way as in a physical laboratory, but a guide with instructions for carrying out the experimentation is also required. Communication between the teaching staff and the learner is usually through the electronic manual, leaving the option for those who have doubts to use the telephone, e-mail or a similar medium (Sowizral et al., 2000; Sebastián et al., 2003).

The virtual laboratories are made up of a mathematical model, algorithms to follow the instructions and be able to follow the model and the conversion of the language through a computer to facilitate the input of information and obtain results.

Importance of Virtual Labs as a strategy in practical teaching

They represent an alternative to be able to perform the practices and repeat them as many times as necessary, and thus reaffirm the knowledge, even without being physically in a traditional laboratory.

Virtual laboratories are computer tools provided by Information and Communication Technologies that simulate a chemical testing laboratory from a virtual environment (Cabero 2007). The virtual modality for teaching experimentation makes it possible for students to study at distant distances and put their knowledge into practice. Compared to a real laboratory, costs are greatly reduced, especially when the appropriate furniture is not available, which generates very high costs for institutions that cannot assume such costs.

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Advantages of using virtual laboratorios

According to Méndez, Monje and Rivas, (2001) the use of virtual laboratories allows to obtain the following benefits:

- Expand course coverage.
- Decrease the costs of transportation, food and lodging for students.
- Simulate situations that in reality would have little chance of being carried out.
- Repeat events or phenomena as many times as required.
- Relate phenomena to their consequences.
- Develop skills in the use of the computer.

The creation of virtual laboratories has multiple advantages over real laboratories. Since this type of laboratories are based on mathematical models that run on computers, their configuration and operation is simpler. In addition, they have a higher degree of safety since there is no risk of accidents in the environment as there is no physical equipment or devices.

Another no less significant advantage derives from economy, since less is invested in equipment, materials and reagents. From the environmental point of view, by not using reagents that are sometimes toxic, the preservation of the environment is favored, since no polluting residues are discharged into the atmosphere or into the drains; in this sense, the health of the students is also ensured since they are not in contact with these materials.

Students learn through trial and error, without fear of suffering or causing an accident, without being ashamed to perform the same practice several times, since they can repeat them without limit; without fear of damaging any tool or equipment (Rosado and Herreros, 2009).

Sousa Ferreira et al. (2021) consider that virtual reality is especially useful when working with events and consequences very close to the daily professional development of a network technician. A practical case is situations in which the student needs to associate hard skills (technical knowledge of programming and cybersecurity to solve problems in computational environments) with soft skills (empathy, emotional intelligence and citizenship education).

Virtual reality is a tool that can help transform educational models, bringing improvements in the teaching-learning process. However, it may not be the most appropriate tool in all cases. Therefore, a thorough analysis of the teacher and all the sectors involved in education is necessary to approach the best model to guarantee learning.

Analysis of results of previous studies

Among the contributions of some authors, Morales Castro's (2015) was considered, where he states that out of 30 respondents, 25 consider that they develop more competencies by practicing virtually, since they can do so whenever they wish without being subject to schedules and the existence of the necessary physical equipment. Therefore, in percentage this is equivalent to an 83% positive response regarding the use of virtual laboratories.

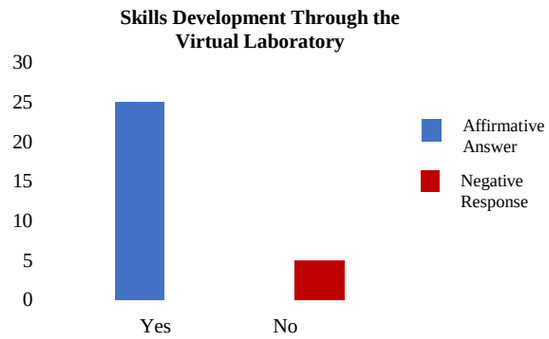

Figure 1 Respondents' opinions
Source: Morales Castro (2015)

The following table shows the competencies that will be developed through the use of virtual laboratories:

Competencies
– Capacity for analysis and synthesis.
– Ability to organize and plan.
– Communication skills.
– Skills in handling technology.
– Research skills.
– Problem solving.
– Decision making.
– Critical thinking.
– Teamwork.
– Responsibility.
– Collaborative learning.
– Exchange of ideas.

Table 1 Competencies to be developed
Source: Morales Castro (2015)

Methodology

The main objective of this research is to recognize that virtual laboratories are a tool that facilitates teaching and learning strategies, so the advantages of using this tool were analyzed through a measurement instrument consisting of 10 questions that reflected the importance of the use of laboratories in quality teaching, by the respondents.

Development of cognitive skills	Frequency of answers			
	Never	Occasionally	Regularly	Always
Clarity and precision	3	7	13	7
Problem solving	4	11	10	5
Technological skills	3	7	15	5
Decision making	4	12	12	2
Confidence in the practice	6	10	10	4
Ideas approach	4	8	15	3
Useful tool as a teaching strategy	Academic Education		Quality Education	
	Yes		No	
	24		6	
	19		11	

Table 2 Aspects evaluated in the measurement instrument
Source: Own contribution December 2021

Table 2 shows the items that were evaluated and the frequencies of the responses that were compiled from the results. A total of 30 instruments were applied to high school students.

Analysis of results

Based on the instruments applied to the 30 students, the results shown in Table 3 were obtained.

Development of cognitive skills	Relative frequency:			
	Never	Occasionally	Regularly	Always
Clarity and precision	0.10	0.23	0.43	0.23
Problem solving	0.13	0.37	0.33	0.17
Technological skills	0.10	0.23	0.50	0.17
Decision making	0.13	0.40	0.40	0.07
Confidence in the practice	0.20	0.33	0.33	0.13
Ideas approach	0.13	0.27	0.50	0.10
Average	0.13	0.31	0.42	0.14
Value in percent	13%	31%	42%	14%
Useful tool as a teaching strategy	Academic Education		Quality Education	
	Yes		No	
	0.80		0.20	
	0.63		0.37	
Average	0.72		0.28	
Value in percent	72%		28%	

Table 3 Relative and average frequency values of evaluated aspects
Source: Own contribution December 2021

In relation to the development of the cognitive skills that are brought down in the use of the virtual laboratory, 42% of the respondents (as shown in Figure 2) develop the competencies mentioned in Table 4 below.

Development of cognitive skills in the use of the virtual laboratory

Competencies to be developed
– Clarity and precision.
– Ease in problem solving.
– Development of technological skills
– Practice in decision making.
– Confidence in internships.
– Ideas approach.

Table 4 Competencies to be developed in the use of virtual laboratories
Source: Own contribution December 2021

The following graph 2 shows the average frequency in which the cognitive skills are developed with the use of the virtual laboratory.

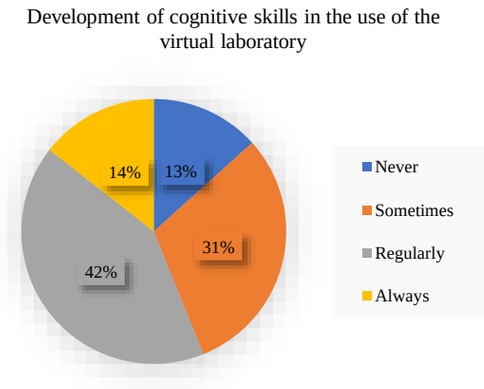

Figure 2 Relative frequency of cognitive skills development in the use of the virtual laboratory
Source: own contribution December 2021

Graphical representation of the impact of the use of the virtual laboratory as a teaching strategy (Graph 3), based on the results shown in Table 2 and Table 3, of the 30 respondents, 24, equivalent to 80%, consider that the use of the virtual laboratory is important for their academic training. Likewise, 11 (63%) agree that the use of the virtual laboratory is a strategy that favors quality teaching.

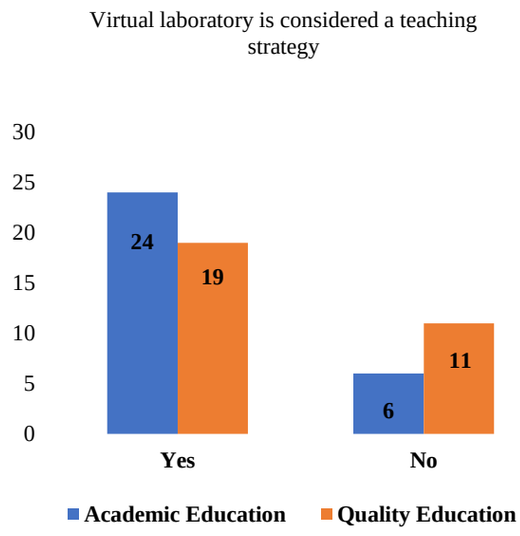

Figure 3 Relative frequency of the importance of the use of the virtual laboratory as a teaching strategy
Source: Own Contribution December 2021

Conclusions

The use of a virtual laboratory facilitates student learning, helps in the repetition of knowledge, you can perform the practice as many times as necessary, offers many advantages ranging from analyzing the scenario of a real situation, to develop skills of analysis and evaluation of results, making the approach of solutions. On the other hand, it encourages the student to feel interest, when part of the knowledge can be felt through the virtual representation, thus giving better results in their performance as students, achieving the goals of teaching, looking for students to achieve critical thinking, to be creative and develop complex cognitive skills, to obtain a quality education. Therefore, it confirms what Morales Castro (2015) said that when using the virtual laboratory, constructivism is applied since the student "learns by doing" by integrating theoretical knowledge with practice, in addition to linking learning with real situations that will be presented in the work environment.

Therefore, the following competitive advantages are developed in the use of the virtual laboratory as:

– Clarity and precision. Performing an internship as many times as necessary to apply theoretical knowledge allows for the development of ideas, which prepares the student to develop his or her decision-making skills.

– Problem solving. Through an initial approach the student is able to assume a conclusion from a result obtained.

– Development of technological skills. This prepares the student and the teacher to interact in a virtual environment, and improves learning, especially in computer science.

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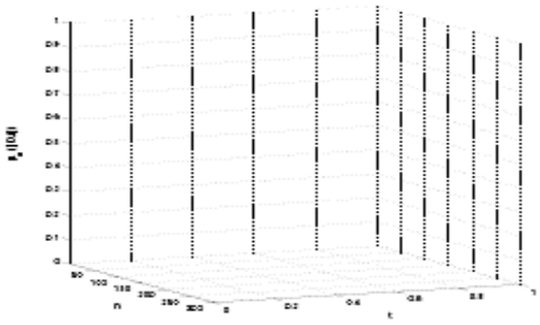

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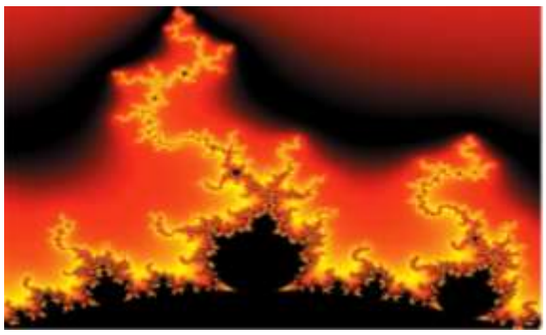

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