ISSN 2531-2952

Volume 4, Issue 15 – July – December – 2020

Journal of Applied Computing

ECORFAN®

Journal of Applied Computing, Volume 4, Number 15, December - 2020, is a biannual Journal edited by ECORFAN-Spain. Matacerquillas Street 38, CP: 28411. Moralzarzal-Madrid. WEB: http://www.ecorfan.org/spain/rj_arquitectura_dis.php, revista@ecorfan.org. Editor in Chief: VALDIVIA - ALTAMIRANO, William Fernando. PhD. ISSN 2531-2952. Responsible for the last update of this issue ECORFAN Computer Unit. ESCAMILLA-BOUCHÁN, Imelda PhD. LUNA-SOTO, Vladimir PhD. Updated as of December 31, 2020.

Journal of Applied Computing

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Presentation of the Content

In Issue 15 is presented an article *Comparison of numerical methods in code as solvers for simulation of robotic systems, by* TORRES-DEL CARMEN, Felipe de Jesús, JARAMILLO-HERNÁNDEZ, Ricardo, DÍAZ-SÁNCHEZ, Arnaldo and NÚÑEZ-ALTAMIRANO, Diego Alfredo, with adscription at Universidad de Guanajuato, in the next article *A review of open-source ventilators for COVID-19*, by ESQUEDA-ELIZONDO, José Jaime, JIMÉNEZ-BERISTÁIN, Laura, MIRANDA-PASCUAL, María Elena and TRUJILLO-TOLEDO, Diego Armando, with adscription at Universidad Autónoma de Baja California, in the next section *Characterization of SARS-CoV-2 cases in Mexico using data mining*, by LUNA-RAMÍREZ, Enrique, SORIA-CRUZ, Jorge, VELARDE-MARTÍNEZ, Apolinar and TAYA-ACOSTA, Edgar Aurelio, with adscription at Tecnológico Nacional de México, Campus El Llano Aguascalientes and Universidad Nacional Jorge Basadre Grohmann, in the next section *Authentic-interactive activities to promote oral production on a virtual platform*, by FLORES-GONZÁLEZ, Norma, with adscription at Benemérita Universidad Autónoma de Puebla.

Content

Article **Journal of Applied Computing**
December 2020 Vol.4 No.15 1-8

Comparison of numerical methods in code as solvers for simulation of robotic systems

Comparación de métodos numéricos en código como solucionadores para simulación de sistemas robóticos

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DOI: 10.35429/JCA.2020.15.4.1.8 Received July 10, 2020; Accepted December 30, 2020

Abstract

This research introduces the development of the implementation and comparison of algorithms of numeric methods which solve a system of ordinary differential equations, commonly known like solvers. These were applied to a robotic system with 4 grades of freedom in open loop based on the non-linear dynamic model in the joint space. The performance of the robotic system solution simulated on Matlab®/Simulink® with S-Function has been assumed to be the reference criterion to contrast the results that were get from codification of the solvers. Moreover, some inferences were set for each one of the algorythms, for instance, simulation time and computing cost. The analysis of the results lets account the implementation of the code of the numeric methods for simulation purposes, thus, it may aid for the optimization of simulation times and computing cost.

Solvers, Numeric methods, Robotic systems

Resumen

Este trabajo presenta el desarrollo de la implementación y comparación de algoritmos de métodos numéricos que resuelvan un sistema de ecuaciones diferenciales ordinarias, comúnmente conocidos como solucionadores. Los cuales fueron aplicados a un sistema robótico de 4 grados de libertad, en lazo abierto, basado en el modelo dinámico no lineal en el espacio de articulación. Se ha considerado el desempeño de la solución del sistema robótico, a través de Matlab®/Simulink® y con el uso de la S-Function, como el criterio de referencia para comparar los resultados obtenidos de la codificación de los solucionadores. Además, se hacen inferencias de los tiempos de simulación de cada uno de los algoritmos. El análisis de los resultados permite considerar la implementación del código de los métodos numéricos para propósitos de simulación, que contribuyan a optimizar los tiempos de simulación y costo computacional.

Solucionadores, Métodos numéricos, Sistemas robóticos

Citation: TORRES-DEL CARMEN, Felipe de Jesús, JARAMILLO-HERNÁNDEZ, Ricardo, DÍAZ-SÁNCHEZ, Arnaldo and NÚÑEZ-ALTAMIRANO, Diego Alfredo. Comparison of numerical methods in code as solvers for simulation of robotic systems. Journal of Applied Computing. 2020. 4-15:1-8.

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Introduction

The use of technology in industrial automation processes has been focused on the application of robotic systems. Rigid manipulative robots in particular have been the subject of research and development for more than two decades. Furthermore, in higher-level educational programs related to robotics, they have been distinguished by the synthesis and analysis of robotic arms of various degrees of freedom (g.d.l.) such as the type PUMA, SCARA, SCORBOT, etc.

The cost of a rigid manipulator is not affordable for the purposes of teaching-learning processes. Therefore, the use of simulations allows to understand the dynamic behavior of a robotic system based on its mathematical model, which is a system of nonlinear ordinary differential equations (ODE), whose solution is carried out through the implementation of method algorithms. numerical, commonly known as solvers.

The most widely used simulation platform in robotics issues is Matlab® / Simulink®, where the solvers that the platform itself has pre-installed are applied; even the simulations in Matlab® / Simulink® have served as a reference for simulations carried out through other software. In this way, in (Velarde *et al*., 2010) a complete simulation of a 5 g.d.l. robot is made. for trajectory tracking in Matlab® / Simulink®; (Gouasmi *et al*., 2012) presents the simulation of the movement of a 2-R robot with a revolutionary configuration, where it is simulated through Solidworks® and compared with the simulation in Matlab® / Simulink®; en (Alshamasin *et al*., 2012) simulates the dynamics of a SCARA robot by means of solid-dynamics software and is verified by the simulation run in Matlab® / Simulink®. Over time, various simulation softwares have been developed, however, Matlab® / Simulink® continues to be the simulation platform used, for example, in (Domazetovska *et al*., 2019), (Cheng *et al*., 2019), (Yoo, 2019), (Orta, 2019) and (Alwan *et al*., 2019).

It is important to note that the configuration of the block diagram in Simulink® allows the use of various solvers, fixed-pitch and variable-pitch, which are already pre-installed in Matlab® software. Even, results of comparisons between the different solvers have been reported, as in (Eshkabilov, 2020) and (Korotchenko and Smoryakova, 2019). However, algorithms in solver code have not been compared to simulate nonlinear systems, which could optimize simulation times and hardware resources.

This work aims to compare the performance of the algorithms of numerical methods such as ODE solvers, developed and implemented in code in Matlab®, which are applied to the dynamic model of a 4 g.d.l. SCARA manipulator robot; the comparison is made taking as a reference the results obtained in simulation carried out on the Simulink® platform using S-Function and the ode45 solver.

The rest of the document is organized as follows: in the Dynamic Model section the mathematical model of the SCARA robot is described; In the ODE Solvers section the algorithms of numerical methods used in the comparison are detailed; the Simulink® Diagram section presents the block model of the SCARA robot simulation, as well as the description of the S-Function that has been used. The Results section shows and analyzes the comparisons and, finally, the conclusions are presented in the corresponding section.

SCARA robot dynamic model

The robotic system to be used in the methodology of this work is a rigid manipulator SCARA (Selective Compliance Articulated Robot Arm) of 4 g.d.l. According to Fig. 1, the arm consists of 3 rotational joints θ_1, θ_2 and θ_3; as well as a translational joint, denoted by d_4.

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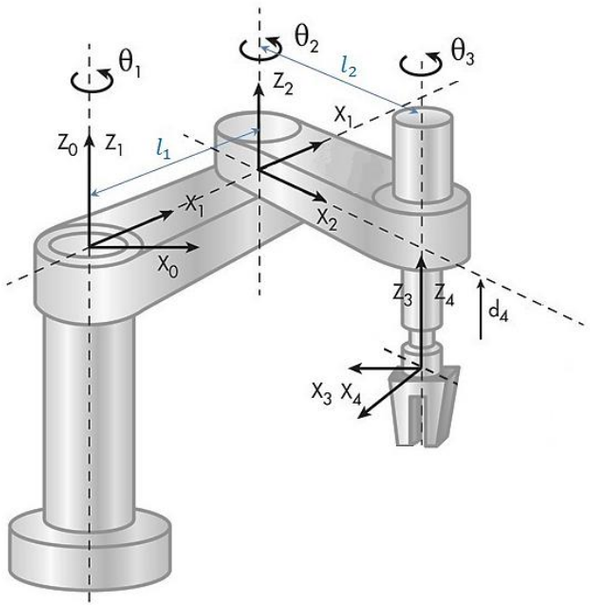

Figure 1 SCARA robot of 4 g.d.l.
Source: Our elaboration

The dynamics of the movement in the articulation space of this manipulator, it is possible to know it through its mathematical model, which is obtained through the Euler-Lagrange methodology, where it has been assumed that the angular positions θ_1, θ_2 and θ_3 will be the generalized coordinates q_1, q_2 and q_3, respectively, and the vertical displacement d_4 of the end effector will be the generalized coordinate q_4. Thus, the dynamic model of the robot, in its matrix representation, is given by:

$$M_i(q_i)\ddot{q}_i + C_i(q_i, \dot{q}_i)\dot{q}_i + B_i\dot{q}_i + g_i(q_i) = \tau_i \quad (1)$$

Where $M_i(q_i) \in R^n$ is the inertia matrix, $C_i(q_i, q_i) \in R^{(n\times n)}$ is the Coriolis matrix and centrifugal forces, Bi is a diagonal matrix of the viscous friction coefficients of each joint, g_i $q_i \in R^n$ is the vector of gravitational forces, $\tau_i \in R^n$ is the vector of input torques or torques. So,

$$\begin{bmatrix} M_{11} & M_{12} & M_{13} & M_{14} \\ M_{21} & M_{22} & M_{23} & M_{24} \\ M_{31} & M_{32} & M_{33} & M_{34} \\ M_{41} & M_{42} & M_{43} & M_{44} \end{bmatrix} \begin{bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \\ \ddot{q}_3 \\ \ddot{q}_4 \end{bmatrix} + \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} \\ C_{21} & C_{22} & C_{23} & C_{24} \\ C_{31} & C_{32} & C_{33} & C_{34} \\ C_{41} & C_{42} & C_{43} & C_{44} \end{bmatrix} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \\ \dot{q}_4 \end{bmatrix} + \begin{bmatrix} B_1 & 0 & 0 & 0 \\ 0 & B_2 & 0 & 0 \\ 0 & 0 & B_3 & 0 \\ 0 & 0 & 0 & B_4 \end{bmatrix} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \\ \dot{q}_4 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ m_4 g \end{bmatrix} = \begin{bmatrix} \tau_1 \\ \tau_2 \\ \tau_3 \\ \tau_4 \end{bmatrix} \quad (2)$$

Where:

$$M_{11} = I_1 + I_2 + I_3 + I_4 + m_1 lc_1^2 + m_2 l_1^2 + m_2(lc_2^2 + 2l_1 lc_2 \cos q_2) + (m_3 + m_4)(l_1^2 + l_2^2 + 2l_1 l_2 \cos q_2)$$

$$M_{12} = I_2 + I_3 + I_4 + m_2(lc_2^2 + l_1 lc_2 \cos q_2) + (m_3 + m_4)(l_2^2 + l_1 l_2 \cos q_2)$$

$$M_{13} = M_{23} = M_{33} = I_3 + I_4$$

$$M_{14} = M_{24} = M_{34} = 0$$

$$M_{22} = I_2 + I_3 + I_4 + m_2 lc_2^2 + (m_3 + m_4) l_2^2$$

$$M_{44} = m_4$$

$$C_{11} = -m_2 l_1 lc_2 \sin q_2 \dot{q}_2 - (m_3 + m_4) l_1 l_2 \sin q_2 \dot{q}_2$$

$$C_{12} = -m_2 l_1 lc_2 \sin q_2 (\dot{q}_1 + \dot{q}_2) - (m_3 + m_4) l_1 l_2 \sin q_2 (\dot{q}_1 + \dot{q}_2)$$

$$C_{21} = m_2 l_1 lc_2 \sin q_2 \dot{q}_1 + (m_3 + m_4) l_1 l_2 \sin q_2 \dot{q}_1$$

$$C_{13} = C_{14} = C_{22} = C_{23} = C_{24} = C_{31} = C_{32} = C_{33} = C_{34} = C_{41} = C_{42} = C_{43} = C_{44} = 0$$

ODE solvers

Numerical methods are algorithms that allow obtaining non-trivial solutions. In particular, a dynamic system such as the SCARA robot is modeled by means of a set of second order nonlinear ordinary differential equations. Therefore, it is necessary to integrate the system of equations twice to obtain the function that represents the angular and translational displacement of each of the robot's joints. This is achieved through the implementation of numerical method algorithms known as solvers.

In the literature there is a great diversity of solvers: those called fixed-step solvers in which the increment of the time vector is a constant number and in each increment the set of ODE is solved; and the so-called variable pitch solvers, in which the increase in the time vector is variable and the set of ODE is also solved at that instant of time given by each increment.

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Euler's method

Let be an initial value problem,

$$\frac{dy}{dt} = f(t, y), y(a) = y_0 \quad (3)$$

To approximate its solution on the interval [a, b], it is necessary to divide the interval into N equal subintervals, such that t_i = a + ih for i = 0,1,…, N with $h = \frac{(b-a)}{N}$.

Where h is known as the step size.

Assuming that y (t) is twice continuously differentiable in [a, b], the Euler integration method is given by (Kharab and Guenther, 2019):

$$y_{i+1} = y_i + hf(t_i, y_i), i = 0,1, \dots, N-1 \quad (4)$$

The code made for this solver is developed in MATLAB® language.

Runge-Kutta method of 4th order

The fourth order Runge-Kutta integration method (RK4) is given by (Kharab and Guenther, 2019):

$$y_{i+1} = y_i + \frac{h}{6}(k_1 + 2k_2 + 2k_3 + k_4) \quad (5)$$

For $i = 0,1, \dots, N-1$, con:

$$k_1 = f(t_i, y_i)$$

$$k_2 = f\left(t_i + \frac{h}{2}, y_i + \frac{h}{2}k_1\right)$$

$$k_3 = f\left(t_i + \frac{h}{2}, y_i + \frac{h}{2}k_2\right)$$

$$k_4 = f(t_i + h, y_i + hk_3)$$

This algorithm has been implemented in MATLAB® language.

Matlab® ode45 solver

Matlab® software has several differential equation solvers pre-installed, including ode45, which is a numerical method based on the 4th and 5th order Runge-Kutta with an adjustment to make a variable step size, which uses a large / small step depending on the function to be solved, if it is smooth enough (continuously differentiable) (Yang *et al*., 2020).

In (Eshkabilov, 2020) it is indicated that the ode45 solver is the one recommended for most ODE problems, therefore, it is the solver that has been chosen to be considered as a reference in the simulations carried out with the other numerical methods.

Simulation in Matlab® / Simulink®

Based on the literature consulted, the simulation platform commonly used for robotic system applications is Simulink® from Matlab®, which also serves as a reference to compare simulations carried out in other software.

In this work, the simulation of the angular behavior of the joints of a SCARA-type robot manipulator was carried out, based on its non-linear dynamic model in the joint space, through the coding of the S-Function Level-1 block of Matlab® / Simulink®. The variable step ode45 solver and a simulation time of 10 seconds have been configured.

An S-Function is a Simulink® one-block computer language description, written in MATLAB®, C, C ++, or Fortran. S-Functions are compiled as MEX files, which are dynamically linked subroutines that the interpreter automatically loads and executes. In particular, the S-Function Level-1 has been encoded in MATLAB® language, therefore, an .m file has been created that is called by the S-Function block. The code used is detailed in Annex A. Fig. 2 shows the simulation scheme carried out in Simulink®.

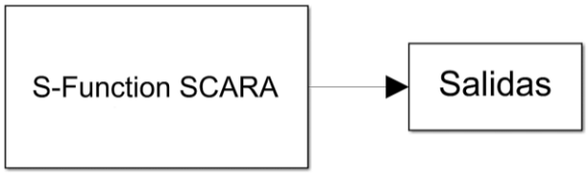

Figure 2 Simulation diagram in Simulink®
Source: Our elaboration

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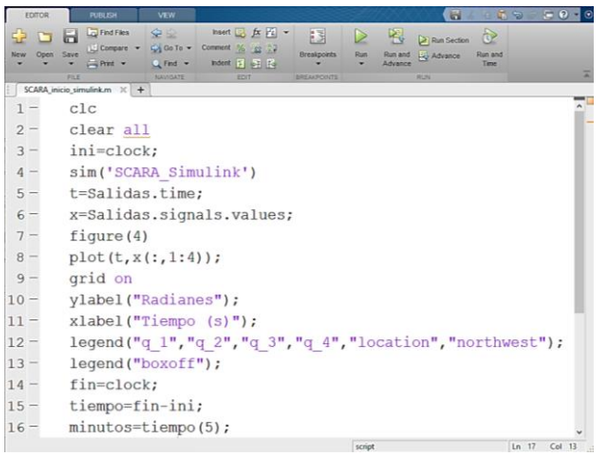
The S-Function Level-1 block allows avoiding the use of different blocks such as integrator, constant, step, gain, etc. and their respective connections, which makes the simulation diagram long and confusing. At the output of the S-Function Level-1 block, a block has been placed to save the value of the variables and the data can be accessed from the Matlab workspace. It is important to note that the option to save the data of the output variables will allow to graph the results of the simulations with the other solvers to make the comparison.

In addition to the block diagram in simulink, programming lines were coded in MATLAB® language to indicate the initial count of the time the simulation takes when it is sent to run, as well as the time at the end and lines of code for the generation of the corresponding graphs, as shown in Fig. 3.



```
clc
clear all
ini=clock;
sim('SCARA_Simulink')
t=Salidas.time;
x=Salidas.signals.values;
figure(4)
plot(t,x(:,1:4));
grid on
ylabel("Radianes");
xlabel("Tiempo (s)");
legend("q_1","q_2","q_3","q_4","location","northwest");
legend("boxoff");
fin=clock;
tiempo=fin-ini;
minutos=tiempo(5);
```

Figure 3. Code to start the simulation in Simulink®
Source: Our elaboration

Simulation results

The results of the simulations carried out of the dynamic behavior of the SCARA robot are presented below. Note that the simulation in Simulink® is taken as the reference path for the other simulations.

The trajectory of each of the robot's joints is plotted, starting from the introduction of excitation input pairs to initiate the movement of the robotic arm. The pairs used are given in Table 1.

	Input torque
q_1	$10sin(0.002\pi t)\ Nm$
q_2	$1+5cos(20\pi t)\ Nm$
q_3	$1+2sin(2\pi t)\ Nm$
q_4	$30\ N$

Table 1 Input pairs to the robotic system
Source: Our elaboration

In all cases, the initial positions of the joints is 0 rad, in addition, the simulation time is 10 seconds.

The simulation in Simulink® was performed with the variable pitch ode45 solver, configured with a maximum pitch and relative tolerance of 1e-3 for both. The RK4 and Euler solvers were carried out with an integration step of 0.01 seconds.

In Fig. 4-7 the trajectories of the joints q_1, q_2, q_3 and q_4 are shown; where the black line represents the result of the simulation carried out in Simulink®, the dotted blue line is the simulation of the 4th order Runge-Kutta solver, the red line corresponds to the code simulation of the ode45 solver (preloaded in Matlab®), finally, with a dotted green line is the trajectory that results from the simulation with the Euler solver.

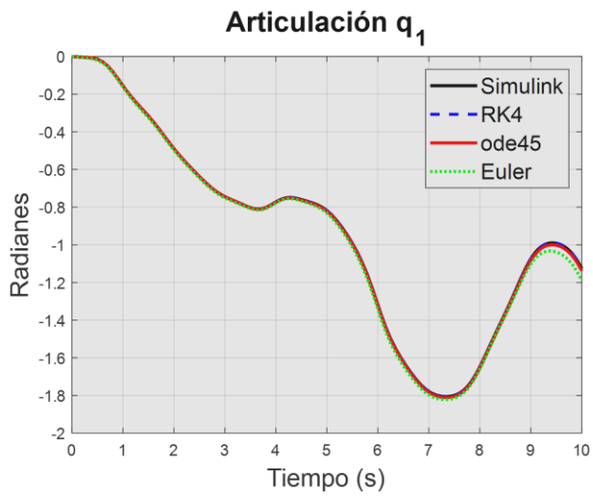


Figure 4 Path of joint q_1 with all solvers
Source: Our elaboration

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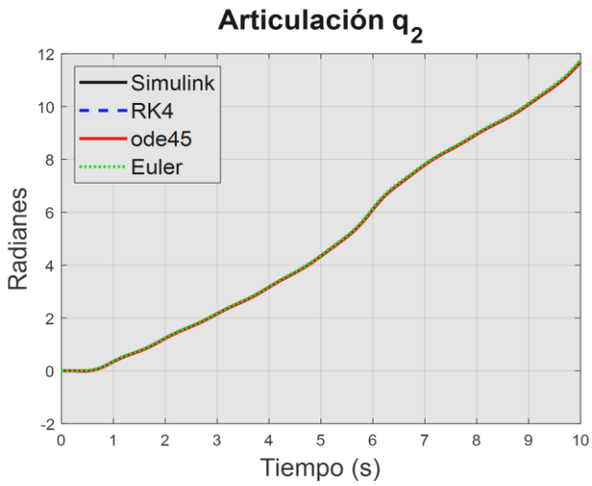

Figure 5 Path of joint q_2 with all solvers
Source: Our elaboration

All the solvers used obtain the same results in joints q_2-q_4 of the SCARA robot, with the exception of joint q_1. This is detailed in Fig. 8, which is a close-up of this trajectory in the time period with the greatest difference between the solvers.

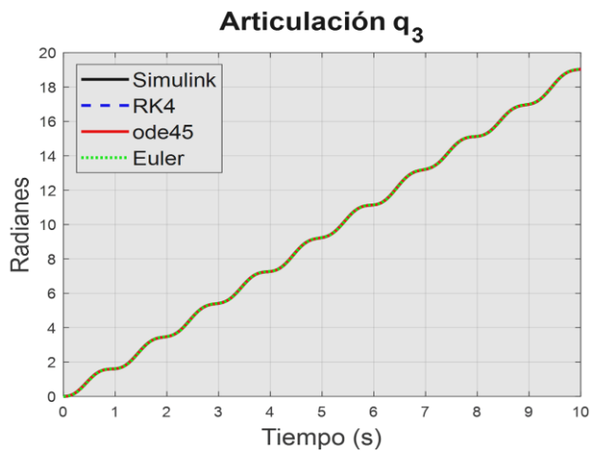

Figure 6 Path of joint q_3 with all solvers
Source: Our elaboration

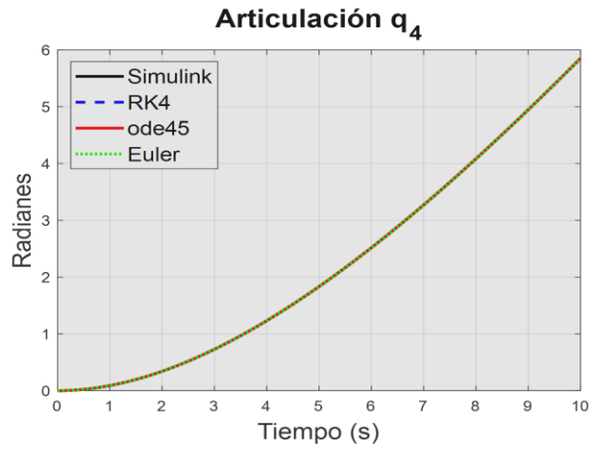

Figure 7 Path of joint q_4 with all solvers
Source: Our elaboration

It is observed that in joint q_1, the RK4 solver correctly follows the path given by the simulation carried out in Simulink®; the other solvers used (ode45 in code and Euler in code) move away from the reference path, this is due to the integration step, which can be reduced to achieve a better approach to the solution offered by Simulink®, however, would have an impact on runtime.

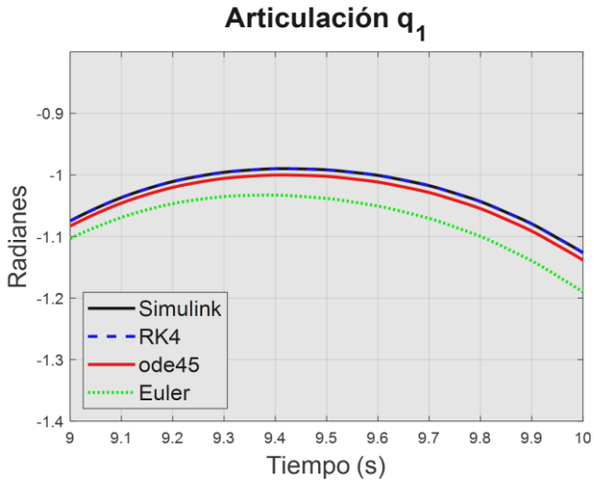

Figure 8 Zoom in on the path of joint q_1 with all solvers
Source: Our elaboration

In addition to the comparison of the trajectories, the analysis is done based on the execution time that each simulation takes to weight the solver with the best performance. For this purpose, the methodology that was followed was to carry out 10 simulations with each of the solvers, then obtain the average of the execution times, these are shown in Table 2.

	Euler code	ode45 code	RK4 code	*Simulink®*
1	0.75	0.81	0.78	2.76
2	0.81	0.76	0.75	2.71
3	0.79	0.80	0.76	2.64
4	0.83	0.83	0.8	2.72
5	0.81	0.78	0.83	2.73
6	0.83	0.83	0.79	2.73
7	0.78	0.80	0.79	2.69
8	0.75	0.78	0.76	2.70
9	0.77	0.85	0.82	2.69
10	0.87	0.83	0.78	2.93
Average	0.799	0.807	0.786	2.73

Table 2 Solver execution times in seconds
Source: Our elaboration

ISSN-2531-2952

Conclusions

Various algorithms of numerical methods, known as solvers, can be used to simulate the dynamic behavior of robotic systems such as the SCARA robot.

In the simulations carried out as teaching-learning activities, widely known software such as Matlab® / Simulink® is commonly used, which uses preloaded solvers in the software installation. However, the code implementation of the numerical methods: Rnge-Kutta of 4th order and the Euler method have shown a correct performance in the developed simulation compared to the simulation done in Simulink®.

According to the graphs of the trajectories, the solver that fully followed the Simulink® simulation is the Runge-Kutta of 4th order in code. In addition, this same solver was the one that presented the best performance according to the execution time, it even had an average execution time less than the time of the Euler method, which is known for its coding simplicity.

Acknowledgments

The authors want to thank the support provided by the University of Guanajuato, Campus Irapuato-Salamanca Engineering Division, for the realization of this project.

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ISSN-2531-2952

Article **Journal of Applied Computing**
December 2020 Vol.4 No.15 9-18

A review of open-source ventilators for COVID-19

Una revisión de los ventiladores de código abierto para el COVID-19

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DOI: 10.35429/JCA.2020.15.4.9.18 Received July 15, 2020; Accepted December 30, 2020

Abstract

In this paper, we present a review of the open-source mechanical ventilators developed worldwide during the beginning of the COVID 19 pandemic. There are many ventilators projects, some Ambu-based, below based and ones that use the air and oxygen lines of the hospital, by controlling the flow and pressure. First, we present the basics of mechanical ventilation concepts. Next, we present an overview of the principal open-source initiatives world, a description of the ventilator, and its working principles. Also, the webpages of each of the projects developed are shown. This paper intends to give the reader a start point of the mechanical ventilators proposed. Finally, we present a compilation developed by the international community where they present the main ventilator projects developed worldwide, where to get their information and the developers' experience. It is important to notice that most of them have not been approved yet by the medical authorities of their respective countries.

Ventilator, Open-Source, COVID-19

Resumen

En este artículo se presenta una revisión de los ventiladores mecánicos de código abierto desarrollados en todo el mundo durante el comienzo de la pandemia de COVID 19. Hay muchos proyectos de ventiladores en el mundo, algunos basados en Ambu, turbinas y otros que usan las líneas de aire y oxígeno del hospital, controlando el flujo y la presión. Primero se presentan los conceptos básicos de ventilación mecánica. A continuación, se presenta una descripción general de las principales iniciativas de código abierto del mundo, una descripción breve del ventilador y sus principios de funcionamiento. También se muestran las páginas web de cada uno de los proyectos desarrollados. Este documento pretende dar al lector un punto de partida de los ventiladores mecánicos propuestos. Finalmente, se presenta una compilación desarrollada por la comunidad internacional donde enlistan los principales proyectos de ventiladores desarrollados en todo el mundo, donde obtener su información y la experiencia de los desarrolladores. Es importante notar que la mayoría de ellos aún no han sido aprobados por las autoridades médicas de sus respectivos países.

Ventilador, Código Abierto, COVID-19

Citation: ESQUEDA-ELIZONDO, José Jaime, JIMÉNEZ-BERISTÁIN, Laura, MIRANDA-PASCUAL, María Elena and TRUJILLO-TOLEDO, Diego Armando. A review of open-source ventilators for COVID-19. Journal of Applied Computing. 2020. 4-15:9-18.

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Introduction

On 11 March 2020, the disease is known as COVID-19, caused by a coronavirus, was declared a pandemic by the World Health Organization (WHO) (Asociación Colombiana de Medicina Crítica y Cuidado Intensivo, 2020; González-Castro et al., 2020; Servicio Murciano de Salud, 2020). As a result, many countries closed their borders and took steps to prevent the spread of the virus (Crowell, 2019).

Globally; China, Italy, the United States, Spain, and Germany are the countries with the highest number of confirmed cases, and are suffering a high demand for medical supplies (Worldometer, 2020).

In Mexico, 8772 confirmed cases and 712 deaths from COVID-19 (México, 2020) have been confirmed in Mexico until April 21st, 2020, as it is shown in Table 2. This table also shows how the number of cases has raised until August 16th up to 517, 714 confirmed cases and 56, 543 deaths.

Date	Confirmed	Negative	Suspicious	Deaths
4/21/20	8,772	32,490	9,653	712
8/16/20	517,714	568,395	89,934	56,543

Table 1 COVID-19 cases in Mexico until April 21st and until August 16th, 2020
Source: (México, 2020)

According to the number of cases reported in the aforementioned countries, the virus's expansion is exponential, at a rate that causes the collapse of health systems in a short time, according to the Ministry of Health (Secretaría de Salud, 2020), the most common symptoms of COVID-19 are fever, cough, sneezing, headache, general discomfort and in more severe cases there is difficulty breathing. Some patients may have pains, nasal congestion, rhinorrhea, sore throat, or diarrhea. These symptoms may be mild and appear gradually. Around 84% of the cases are recovered (Worldometer, 2020).

In contrast to the above, on average, 4% develop a serious and critical state (Worldometer, 2020). In these cases, where the most serious symptoms such as shortness of breath occur, techniques and equipment are used to assist the patient, such as mechanical fans.

So, the patients will require oxygen therapy coupled with mechanical ventilation to support adequate oxygen saturation (>88%) in arterial (Andreoli, Benjamin, Grigss, & Wing, 2015). The cost of a machine ranges from $12,500 to 800,000 pesos each fan as reported in this year's financial year by the health sector (Gobierno de México, 2020). So, here we present a review of the open-source ventilators, developed worldwide to give a chance to people infected with Covid-19. There are two main kinds of PAVs proposed: pre-stage public access ventilator (PAV) and the ones based on artificial manual breathing unit (AMBU) bags with electric blowers to act as emergency ventilators (Pearce, 2020a).

Mechanical Ventilators classification

The mechanical ventilators can be classified on what factor terminates inspiratory flow: 1) pressure-cycled ventilators terminate flow when pre-set pressures are reached in airways; 2) volume-cycled ventilators provide a set volume of gas to the patient over a range of pressures, with a maximum pressure that had been set to avoid damage to the patient's lungs during delivery of the set tidal volume; 3) time-cycled ventilators set tidal volume by setting the inspiratory time and flow rate, and 4) flow cycled ventilators, where the inspiratory flow is terminated when the inspiratory flow rate drops below a specific level (Pearce, 2020b).

Mechanical Ventilators parameters

The most common commercial modes of mechanical ventilation both provide a specified number of breaths per minute (BPM) and are: 1) synchronized intermittent mandatory ventilation (SIMV) where patients can take additional breadths over the set rate and 2) assist control (AC) that uses triggering so that if the patient makes an effort to breathe, it helps them, and if not, it maintains the set rate. These modes can be used alone or in concert with 1) continuous positive airway pressure (CPAP), which uses a high-pressure reservoir and constant flow of gas that exceeds the patient's needs; 2) positive end-expiratory pressure (PEEP), which increases the residual reserve capacity and allows for many alveoli and small airways to remain open that would otherwise close off; or 3) pressure support ventilation (PSV), which adjusts the pressure on the fly as the patient breathes to maintain a pre-set inspiratory pressure.

ISSN-2531-2952

For those designing open-source ventilators using any of those modes and methods, there is a good base of established literature to draw upon (Pearce, 2020b). Both kinds of ventilators were designed using low-cost technologies that were available.

Open-source ventilators

There are several commercial low-cost products like the Pumani bubble CPAP for infants, D-box, or One Breath Ventilators, which could be used to relieve some of the demand for conventional ventilators. In this paper, we do not try to make a market review of such devices, instead, we focus on the open-source ventilators.

Open-source designs shared worldwide

Since the pandemic has affected so many countries, an increase in these types of equipment developed at low cost has been developed these days (Crowell, 2019) (OxyGen Project, 2020).

These systems have already been developed since a couple of years ago, like the ones of (Crowell, 2019) (Williams, 2019), therefore it is considered to be a suitable design for these circumstances, thus ensuring that the function is correct. Likewise, these developments have been reviewed by teams from different countries and various disciplines such as mechanical, electrical, electronic, and medical engineers, testing against different realities. In short, these prototypes have already been successfully tested in different settings, so they were shared with the altruistic purpose of helping people in need.

OxyGEN project, Spain

It is a collaborative hardware project initiated and directed by Protofy.xyz, a Spanish company based in Barcelona, in charge of providing innovative hardware and software solutions. This project's mission is to provide a chance for survival to those who do not have access to a medical artificial ventilator for any reason. For this, they created an open, low-cost hardware system with simple and easily available components, based on the automation of a manual resuscitator (Ambu-bag), with the idea of contributing to saving lives (OxyGen Project, 2020).

It has received the approval of the AEMPS (Spanish Agency for Medicines and Health Products) to start its use on patients at all hospitals that adhere to the clinical study. Figure 1 shows the prototype of the OxyGEN project, notice that it is based on the compression of an Ambu bag using a cam system. The information and the project's webpage can be found at https://www.oxygen.protofy.xyz.

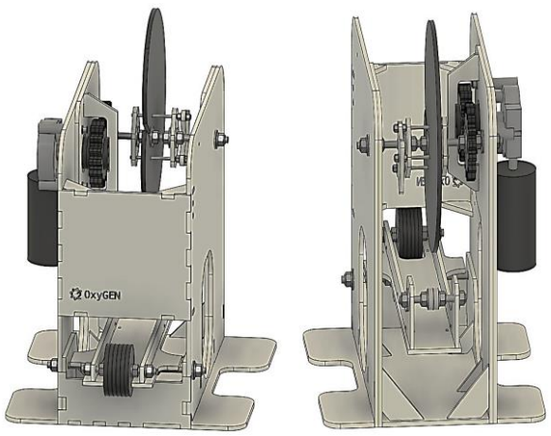

Figure 1 OxyGen project
Source: (OxyGen Project, 2020).

Open Source Ventilator (OSV), Ireland

The Irish OSV company founded by Colin Keogh, Conall Laverty, and David Pollard, to build a team focused on Ireland developing a collaborative Field Emergency Ventilator (FEV) with the Irish Health Service ((OSCMS), 2020). To date, they have formed a team of engineers, designers, and medical professionals to develop new low-resource interventions, all working collaboratively online. Traditionally manufactured and bagged valve masks (BVMs), 3D printed components are being considered to maximize potential manufacturing capabilities. It is a fast-deploying, low-resource, open-source (in progress) fan design that uses a valve bag-mask (BVM or Ambu-bag) as the core component. The block diagram of this project is shown in figure 2 and it can be noticed. The information of this project can be found at https://gitlab.com/open-source-ventilator/ventilator/OpenLung

ISSN-2531-2952

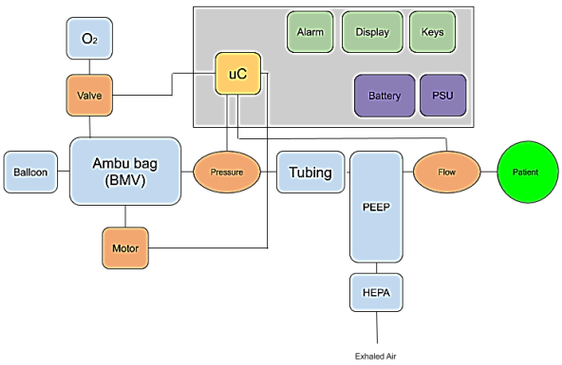

Figure 2 Diagram of the Open Source Ventilator from Ireland
Source: ((OSCMS), 2020).

Project OpenAir, Portugal

They work on medical devices to provide a simple and fast solution that can be reproduced and assembled anywhere in the world. This prototype implements the pressure-controlled continuous mandatory ventilation mode (PC-CMV) with settable breathing rates, inspiration/expiration time ratios, and FiO_2 modulation. Pure oxygen at the standard pressure of 4 bar (400 kPa) is fed from the hospital supply to an adjustable pressure regulator with an output range of 20 to 40 mbar, allowing the PIP pressure to be set by just turning a knob. The regulator output is fed to the inspiration electro valve that should have enough aperture for the air to pass through easily at normal breathing flows (Pereira et al., 2020a). This prototype is shown in figure 3. The details of this project can be found at https://projectopenair.org/en/home-2/.

Figure 3 OpenAir final prototype
Source: (Pereira et al., 2020b)

RespiraWorks, USA, Guatemala, Kyrgyzstan

They are a team with backgrounds in medical devices, quality assurance, nuclear power, submarine life, and project management. They are located in Berkeley, Denver, Guatemala, Kyrgyzstan, and places around the world. They are working on an emergency ventilator, based on a blower and shown in figure 4, to address the looming shortage in the developing world (RespiraWorks, 2020) and their webpage is https://respira.works/. Their cost is under USD 500.

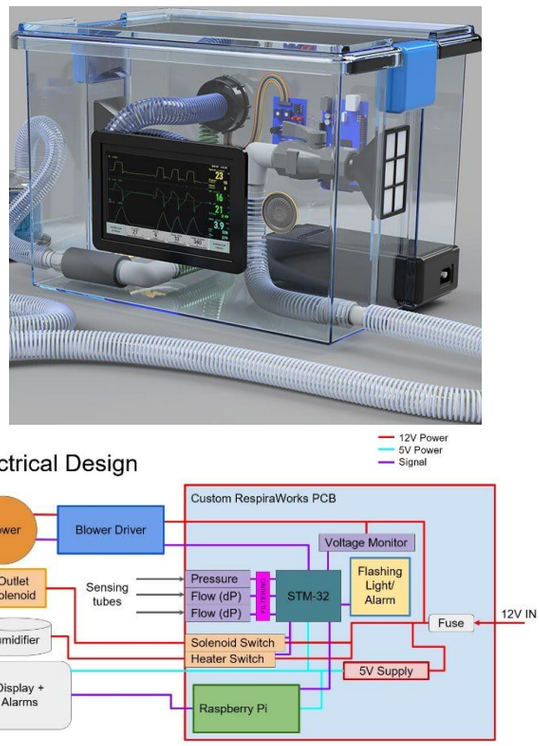

Figure 4 Respira Works project and the electrical diagram
Source: (RespiraWorks, 2020)

The Pandemic Ventilator Project, USA

The Pandemic Ventilator Project is an open-source hardware project and the information presented of this project is only for development and investigative purposes. The prototypes presented are not fully functional devices and have had no safety testing done. This project consists of the bellows unit, which is made of wood, valves and piping, a PLC controller, some wires and switches, and a power supply unit.

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The whole unit is mounted on a piece of 1/2 inch thick plywood that is 18 inches by 21 inches. a device agrees to waive any liability. The information on this project (Instructables, 2020) can be found at https://www.instructables.com/id/The-Pandemic-Ventilator/. Figure 5 shows a diagram of this ventilator based on a bellow.

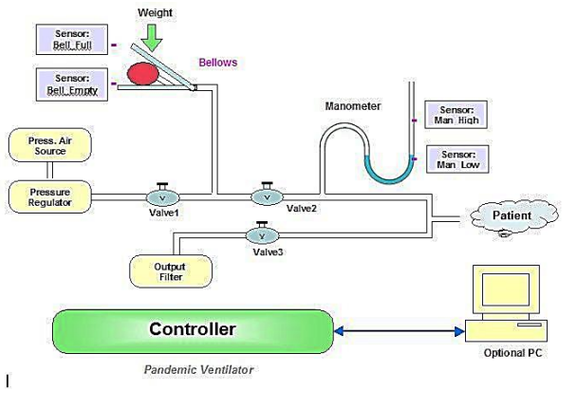

Figure 5 Pandemic Ventilator
Source: (Instructables, 2020).

MIT Emergency Ventilator (E-Vent) Project

This project is based on automating a manual resuscitator, as a potential means for longer-term ventilation. This is a completely off-label use, but they recognize the global interest when a hospital has used up all ventilators and the only option is manual bagging a patient. This may allow less severe patients to be cared for by less specialized clinicians, while resources are focused on those most in need. It has a 12V DC @ 5A power supply and is based on the open hardware platform Arduino UNO. Figure 6 shows the electrical system architecture of this project (MIT, 2020) and the information is available at https://e-vent.mit.edu/.

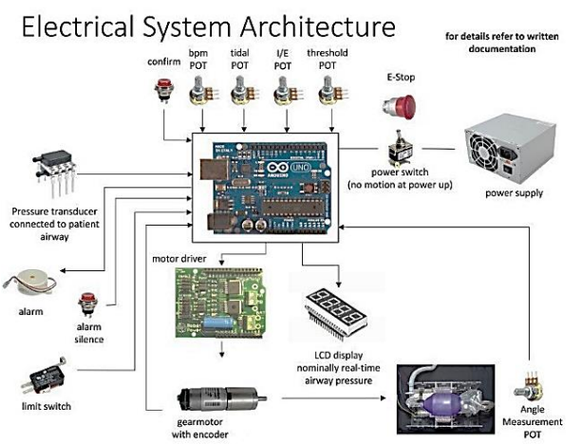

Figure 6 MIT E-Vent project diagram
Source: (MIT, 2020)

Open Source Ventilator Project, University of Florida

It is a ventilator system for adults (older adults at higher risk) based on positive pressure-volume control for intubated patients who do not breathe spontaneously. The designs are modular, allowing different modules to be combined according to local availability. It has an out of box design: all parts are commercially accessible.

The design is inexpensive to build (parts for the base model are estimated to be under $ 300) and assembles quickly (in less than TBD hours) with easily accessible parts (Florida, 2020). The information on this project can be found at https://simulation.health.ufl.edu/technology-development/open-source-ventilator-project/. Figure 7 shows the diagram of this project, and we can notice the pneumatics of this ventilator.

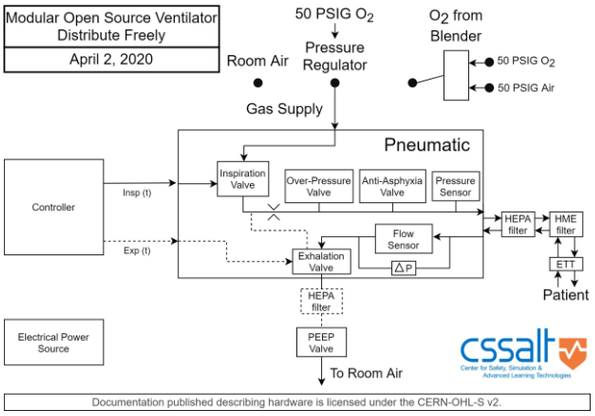

Figure 7 Open Source Ventilator Project diagram
Source: (Florida University, 2020)

Puritan Bennett 560 (PB 560), USA

This device plans were released by Medtronic to help people in the COVID 19 pandemic. It is pump-based and it was designed in 2010, so it has been a long time in use (Medtronic, 2020). This device is more complicated to build and also more expensive, but probably offers more features, and has already been approved by numerous governments. Another fact is that some of the elements are discontinued now and it is not easy to find them. Also, some industrial facilities are needed to build them. Figure 8 shows the Puritan Bennett 560 device.

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Figure 8 Puritan Bennett 560 ventilator
Source: (Medtronic, 2020)

The information on this ventilator can be found at https://www.medtronic.com/us-en/e/open-files.html?cmpid=vanity_url_medtronic_com_openventilator_Corp_US_Covid19_FY20, after filling a form.

AmboVent, Israel

"AmboVent" is a device inspired by the bag-valve-mask ventilators that paramedics use when they're manually ventilating patients in an ambulance, which also offers controls for respiration rate, volume, and maximum peak pressure. The device is being developed as a global partnership for the greater good, in open-source code mentality, on a non-profit basis to enable free and simple mass production by anyone, anywhere in the world. It is designed as an alternative automatic, controlled, ventilation system for adults, to be used only in emergencies when no other approved ventilation machines are available (Israel Air Force, 2020). Figure 9 shows the AmboVent project and all the information on this project can be found at https://members.smoove.io//view.ashx?message=h44741568O122392748O219654O122323322&r=1009.

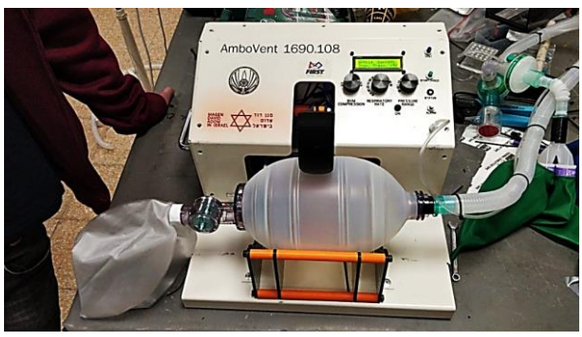

Figure 9 AmboVent project, final design
Source: (Sloan, 2020).

Other international efforts

Also, at (Read, 2020) is published a classified Analysis of Open Source COVID-19 Pandemic Ventilator Projects, that can also be found at https://github.com/PubInv/covid19-vent-list, developed worldwide. This site has the goal to be helpful to those looking for quick information, and not to disparage any project. The ventilation projects are qualified from 0 or 1 to 5, in seven categories: Openness, Community Support, Buildability, Functionally Tested, Reliability Tested, COVID-19 Suitability, Clinician Friendly. Figure 10 shows the spreadsheet that contains the information of the analysis made of these ventilators' projects. The direct link to this spreadsheet is https://docs.google.com/spreadsheets/d/1inYw5H4RiL0AC_J9vPWzJxXCdlkMLPBRdPgEVKF8DZw/edit#gid=0 (Read, 2020). Also, there is placed an email if there is a need to contact the developer's team. Next, these classification criteria are explained.

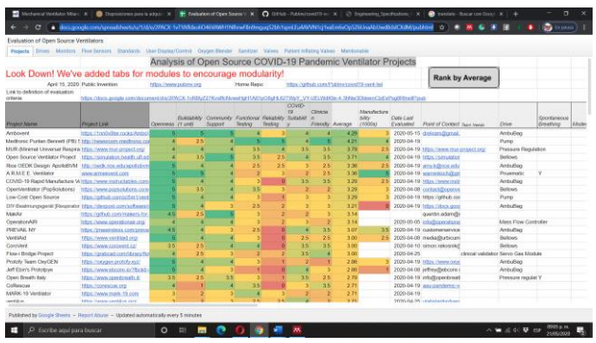

Figure 10 Analysis of Open Source COVID-19 Pandemic Ventilator Projects
Source: (Read, 2020).

The qualifications for these seven attributes are:

Openness

- Not Open
- Declared to be open, but no plans published
- Have a repo with at least some plans?
- Has a clear license strategy, regular updates to plans?
- Fully open, everything document, responsive community, clear license.

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Buildability

- Unbuildable.
- Documents available but they require guesswork.
- All software and hardware transparent and documented. Some manufacturing instructions, such as a build video.
- Complete documentations suggested reproducibility.
- Has been successfully reproduced by another team purely from documentation.

Community Support

- Inactive; not point of contact.
- Point of contact, but unresponsive.
- Responsive leader or manager, more than one volunteer.
- Active community, weekly activity, and reports git-repo or other shared documents.
- Large, active, open community.

Functional Testing

- In Design Phase, Not listed/tested.
- Makes a bag move.
- Tested with a test lung.
- Tested for pressure and volume limits, with breath rate control.
- Tested for alarms, multiple modes, O_2 mixing.
- All test green (if asserted as a feature).

Reliability Testing

- Not Listed.
- Operates for one hour.
- Operates for 12 hours.
- Operates for 12 hours passing all functional test acceptably (low exception rate).
- Independent team operates for 48 hours passing all functional tests, data logs reviewed.
- Mean time between failure data starting to become meaningful.

COVID-19 Suitability

- In design phase/Not listed.
- Operates with supplemental oxygen.
- Pressure or volume control or both.
- PEEP.
- Sophisticated alarm capability and stabilizable of all patient contact points.
- Meets British RVMSv1 standards.

Clinician Friendly

- Unknown controls.
- No controls.
- Breath rate and volume control, standard ports.
- Breath rate, volume, and pressure control easy to set, standard ports, clear external labeling graphically and in the language of choice.
- Alarms easy to set and understand, wholesale replication of an existing UI or conformance to a TBD UI standard.
- Data logging, informative, easy control, battery backup for moving. No training is needed in normal operation due to similarity with familiar designs.

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Manufacturability (1000s)

Note: This is usually zero until the Buildability of (1) unit (separate column) reaches 4.

- Insufficient plans to duplicate a single unit.
- Bill of Materials (BOM) clear.
- 2d parts, 3d parts, code, all clearly documented.
- Electrical schematics and air circuit schematics clear. PCBs if any present and documented. Wiring if required fully documented.
- Basic instructions and special instructions present. Video instructions helpful. Documented in the language of choice, preferable more than one. Basic description of "smoke tests" and simple quality assurance present.
- Either evidence of BOM availability in units of 1000, or supply-chain flexibility of parts suggesting same. Documentation for handling supply-chain disruption present if minimal. Plans include manufacturing issues for non-expert workers. Detailed quality assurance plans present.

With this information, the people interested in building open source ventilators can have an idea of what project follow, according to their needs and the supplies available. More information about these criteria can be found at https://docs.google.com/document/d/e/2PACX-1vRl9yZ27KvslftcNvweHgH1A81pO8gHL62TWpY_VY-UELWdK9x-4-3hNw3DbkemClzExPsg8RfnxilP/pub (Read, 2020).

Reviewed projects at the Analysis of Open Source COVID-19 Pandemic Ventilator Projects

Table 2 shows some of the information presented at the Analysis of Open Source COVID-19 Pandemic Ventilator Projects, like the average obtained of all the projects presented in this paper and the same order.

In the first column, the Project's Name is presented. Next, the origin country where the project was developed is presented. The third column says if it is driven by Ambu bag, Positive Pressure Control, Fan, Bellow, or Pump. The fourth columns present the Buildability (Build) qualification obtained in the revision. Finally, the last column shows the average of all the parameters analyzed.

The Puritan Bennett 560 and the AmboVent had the top average of 4.45 but is important to notice that the Puritan Bennet has been developed by a medical company in 2010, released for the pandemic and some of their core components are not easy to find. Also, the Puritan Bennet got a score of 2.5 in Buildability because of this condition. On the other hand, the AmboVent has been developed with more common components, and it has the same final average, but with a qualification of 5 in Buildability. In the second place, we have the Respira Works project, with an average of 3.25 and a Buildability qualification of 4. In third place, we have the Open Source Ventilator of the University of Florida with an average of 3.15 and a Buildability score of 3.5. The OxyGEN, located in the fourth place, the project got an average of 2.95 with a Buildability qualification of 4. The E-Vent got an average of 2.80 and a Buildability qualification of 3, so it was located in fifth place. All of these projects presented above got an average over the mean of 2.5. The Pandemic Ventilator got an average of 1.30, the Open Source Ventilator form Ireland got an average of 0.90 and the Open-Air project got an average of 0.70.

Project	Country	Drive	Build	Average
OxyGEN	Spain	Ambu bag	4	2.95
OSV	Ireland	Ambu bag	2	0.90
Open Air	Portugal	Pressure Control	1	0.70
Respira Works	USA-Guatemala	Fan	4	3.25
Pandemic Ventilator	USA	Bellow	1	1.30
E-Vent	USA	Ambu bag	3	2.80
Open Source Ventilator	USA	Positive Pressure Control	3.5	3.15
Puritan Bennett 560	USA	Pump	2.5	4.45
AmboVent	Israel	Ambu bag	5	4.45

Table 2 Comparison of the analyzed projects
Source: Self-made

ISSN-2531-2952

Conclusions

There are a lot of different projects for designing and replicating ventilators for people in this COVID 19 pandemic. We can conclude that most of the projects developed worldwide are not approved yet for medical use, except for the OxyGen Project and the Medtronic's Puritan Bennett 560, but the buildability parameter is very important. The information collected and classified in the Analysis of Open Source COVID-19 Pandemic Ventilator Projects is very useful to know the international experiences obtained in the design and construction of these ventilators. Also, there are different kinds of ventilators, so anyone can choose the one who fits the needs of their local community.

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ISSN-2531-2952

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ISSN-2531-2952

Article **Journal of Applied Computing**
December 2020 Vol.4 No.15 19-25

Characterization of SARS-CoV-2 cases in Mexico using data mining

Caracterización de casos SARS-CoV-2 en México utilizando minería de datos

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DOI: 10.35429/JCA.2020.15.4.19.25 Received July 20, 2020; Accepted December 30, 2020

Abstract

In this paper, it is realized an analysis of the data published by the Federal Government of Mexico on the cases related to the test for detecting the presence of the SARS-CoV-2 virus, that originates the COVID-19 disease. More than a million cases were analyzed, most of which were positive to the test. For this study, twenty-one significant variables were considered, included the result of the test and the cases of death, going through the different factors that complicate a person's health such as diabetes, chronic obstructive pulmonary disease (COPD), asthma, hypertension, obesity and smoking, among others. At the beginning of the study, the preparation of the data was carried out so that they could be treated using data mining techniques, based on the CRISP-DM methodology for extraction of knowledge. Thus, with the help of this type of techniques, data models were generated to characterize the development of the COVID-19 disease in the national and local (by States) panorama. As an important part of the models, various rules or correlations were observed among the different variables, which could be used to predict, in part, the future development of the COVID-19 disease in Mexico and, consequently, to establish best practices that target to reduce its social impact.

COVID-19, Data mining

Resumen

En este artículo, se realiza un análisis de los datos publicados por el Gobierno Federal de México sobre los casos relacionados con la prueba para detectar la presencia del virus SARS-Cov-2, que da origen a la enfermedad COVID-19. Se analizaron más de un millón de casos, la mayor parte de los cuales dio positivo a dicha prueba. Para este estudio, se consideraron veintiún variables significativas, que incluyen el resultado de la prueba y los casos de fallecimiento, pasando por los diferentes factores que comprometen la salud de una persona tales como la diabetes, la enfermedad pulmonar obstructiva crónica (EPOC), el asma, la hipertensión, la obesidad y el tabaquismo, entre otros. Como inicio del estudio, se llevo a cabo la preparación de los datos de manera que pudieran ser tratados mediante técnicas de minería de datos, tomando como base la metodología CRISP-DM para la extracción de conocimiento. Así, con la ayuda de este tipo de técnicas, se generaron modelos de datos que permitieron caracterizar el desarrollo de la enfermedad COVID-19 en el panorama nacional y local (por entidades). Como parte importante de los modelos, se observaron diversas reglas o correlaciones entre las diferentes variables, mismas que pudiesen ser utilizadas para predecir, en parte, el desarrollo futuro de la enfermedad COVID-19 en México y, consecuentemente, para establecer mejores prácticas que apunten a reducir su impacto social.

COVID-19, Minería de datos

Citation: LUNA-RAMÍREZ, Enrique, SORIA-CRUZ, Jorge, VELARDE-MARTÍNEZ, Apolinar and TAYA-ACOSTA, Edgar Aurelio. Characterization of SARS-CoV-2 cases in Mexico using data mining. Journal of Applied Computing. 2020. 4-15:19-25.

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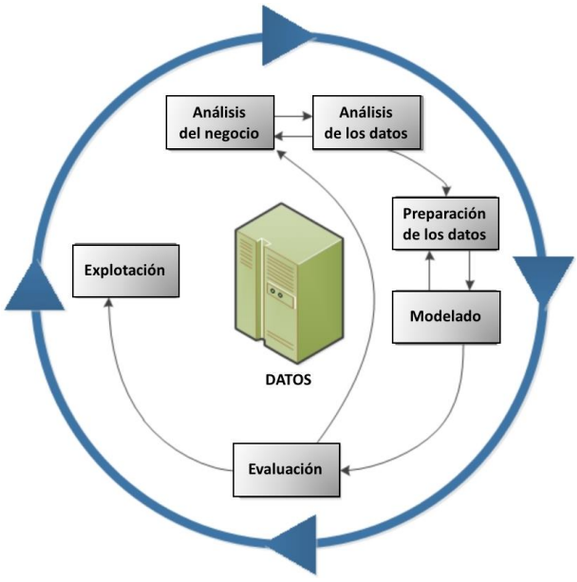
Introduction

The current situation in the world around the COVID-19 disease, caused by the SARS-CoV-2 virus, is extremely worrying, so that any effort aimed at contributing to the solution to this pandemic it could be subceptible of consideration based on the originality of the proposal that is made. In this sense, this article describes a study that is being carried out on the statistics published by the Federal Government of Mexico on the official portal of the COVID-19 disease (https://coronavirus.gob.mx/).

Our study consists of analyzing the published data from a data mining perspective, that is, applying machine learning techniques to extract hidden knowledge in the data that allows detecting patterns in the social spread of the SARS-CoV-2 virus, as well as in deaths and in recovered cases of the COVID-19 disease.

It is important to note that as an initial part of our work, it has been necessary to treat the original data based on the standard methodology of the data mining process, called CRISP-DM and illustrated in Graphic 1.



Graphic 1 Cyclical data mining process

During the initial phase, that of data analysis, 21 significant variables were identified for the study, 3 of which are related to the geographical location of each case, that is, the State and Municipality of residence, as well as the State. where attention was paid to the cases; 12 more variables, referring to conditions that could complicate the COVID-19 disease, which are illustrated in Table 1, foliated from # 8 to # 19.

Thus, in this table, it can be seen that such conditions range from PNEUMONIA to SMOKING.

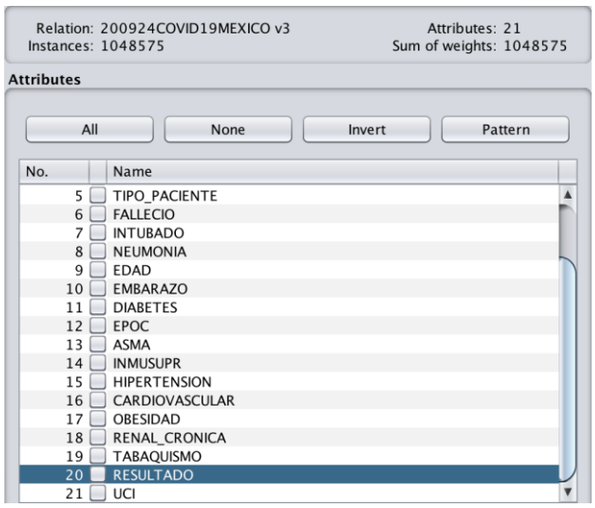


Table 1 List of significant variables

In the previous Table, it can also be seen that the number of cases originally analyzed was more than one million, specifically, 1,048,575 cases. The other 6 variables refer to SEX (Woman, Man), PATIENT_TYPE (Outpatient, Hospitalized), ICU - Intensive care unit (Yes, No), INTUBATED (Yes, No), DEATH (Yes, No) and RESULT (Positive, Not positive, Pending).

In this way, the data published by the Federal Government were prepared to be processed using data mining techniques, which have helped generate models to represent hidden knowledge in the data. The models generated have been evaluated with ad-hoc algorithms to measure their performance in the task of predicting specific aspects of the evolution of the COVID-19 disease, in the near future. That is, the models contain some rules in which correlations between the study variables can be observed, which precisely help to make predictions on aspects of interest.

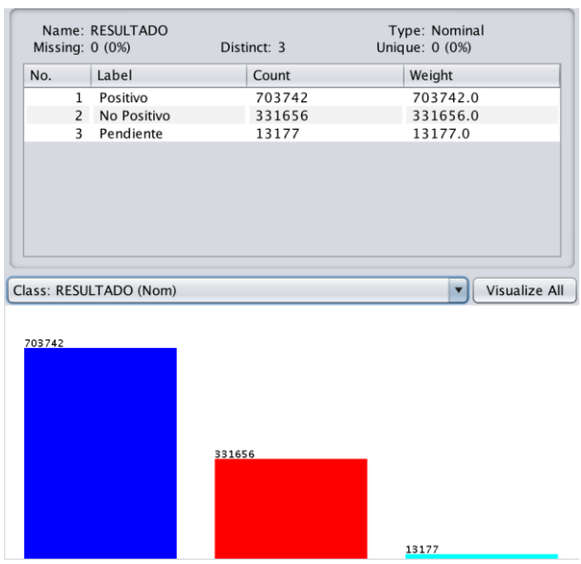
This article has been developed in four sections, including this introduction. The following sections describe the applied methodology, the results obtained so far and the corresponding conclusions in greater detail. In the end, the references.

ISSN-2531-2952

Methodology

First, it is important to mention that for our study the data from six months after the date on which phase 2 of the coronavirus was dictated in Mexico was used, that is, the data published up to September 24, 2020. However, the models generated, having been evaluated, are precisely intended to operate in future scenarios.

Thus, as mentioned in the previous section, for this work, we are based on the CRISP-DM methodology, so that as an initial part of the exploitation of the preprocessed data, prior to the generation of models, we carry out a segmentation that allowed to approach the analysis of the data in a more objective way. In the first instance, the cases that tested positive for the SARS-CoV-2 virus were fully identified, which automatically reduced the number of case studies from one million to just over seven hundred thousand. Graphic 2 shows the segmentation carried out around the test result, where the highest bar corresponds to positive cases, while the central bar and the lowest bar correspond to the cases that gave negative to the test and undiagnosed cases, respectively.

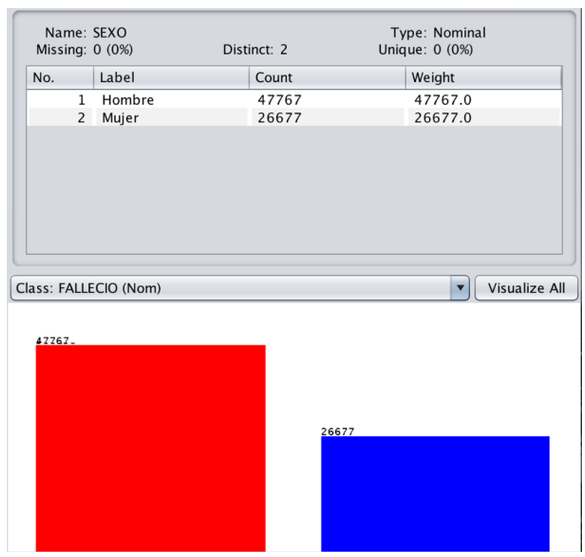


Graphic 2 Identification of positive cases

In this way, the study has only been carried out on cases that tested positive for the SARS-CoV-2 virus, which allowed us to better characterize the behavior of the COVID-19 disease in Mexican society. Thus, for example, Graphic 3 shows the number of positive cases based on the variable SEX.

Graphic 3 Segmentation of positive cases by sex

In this Graphic, it can be seen that the number of infections between women and men is almost on par, 48% in women and 52% in men. However, when segmenting based on the number of deaths, the situation changes considerably, as can be seen in Graphic 4.



Graphic 4 Segmentation of deaths by sex

64% of deaths in men against 36% of deaths in women, shows a ratio of almost 2 men killed for every woman killed, which outlines the fact of being a man as a risk factor at the time of suffering from COVID-19.

In the previous Graphic, it is also possible to observe (calculate) the total number of deaths that occurred within the set of positive cases, this is 74,444 deaths out of 703,742 positives, which yields a 10.57% mortality in Mexico.

ISSN-2531-2952

As an important part of the beginning of our research, in addition to the preliminary treatment (segmentation) of the data presented previously, several works related to our topic of interest were reviewed, that is, the prediction models of the evolution of the COVID-19 disease. 19, the results of which aim to contribute to its control. Some of these works are described below.

Meng *et al*., (2020) describe the development of a densely connected artificial neural network, called De-COVID19-Net, aimed at predicting the probability that a patient with COVID-19 progresses to a high-risk state, or failing that, to a state low risk. For the development of their work, the authors used diagnostic imaging studies (X-rays, computed tomography ...) and clinical information from a sample of 366 patients, which included 70 patients who died within a period of 14 days, counted from taking their studies (high-risk patients) and 296 who survived more than 14 days or were cured (labeled low-risk patients).

Qjidaa *et al*., (2020) describe the development of an intelligent clinical decision support system, called SADC (for its acronym in English), aimed at the early diagnosis of the COVID-19 disease from the taking of X-rays in the chest of a sample of 566 people from rural areas. For the development of their work, the authors use Deep Learning algorithms to classify radiological images into three classes (COVID19 class, pneumonia class and normal type class); build a model by mixing the results of the predictions of seven pre-trained neural network models on the diagnosis of the test for COVID-19 disease. According to the authors, their model achieves high precision in said diagnosis (98.66%).

Roy *et al*., (2020) describe the development of an online platform, called Covid-19 Predictor, aimed at predicting confirmed and affected cases, as well as deaths from COVID-19 in India, using data from an open repository. . His work was developed under a three-phase methodology: the extraction of data from the repository (and its preparation), the implementation of the model to predict the data of the pandemic and the implementation of the access interface to the online platform.

Results

Once the data had been prepared and segmented, various models were generated using Weka (https://www.cs.waikato.ac.nz/ml/weka/), a free tool on the Internet that contains various classification algorithms, grouping and association, as well as algorithms to evaluate models. In the first instance, various classifiers were applied to the set of positive cases, obtaining the best result so far with the PART classifier, which underlies the idea "divide and conquer". This algorithm builds a partial decision tree in each iteration based on the C4.5 algorithm (Chauhan & Chauhan, 2013) and assumes the best sheet as a rule. In Table 2, the generated model is presented, having obtained 92% of correctly classified data.

```
=== Run information ===

Scheme:       weka.classifiers.rules.PART -C 0.25 -M 2
Relation:     0 200924COVID19 MEXICO Positivos-weka.filters
Instances:    703742
Attributes:   18
              ENTIDAD_UM
              SEXO
              TIPO_PACIENTE
              FALLECIO
              INTUBADO
              NEUMONIA
              EDAD
              EMBARAZO
              DIABETES
              EPOC
              ASMA
              INMUSUPR
              HIPERTENSION
              CARDIOVASCULAR
              OBESIDAD
              RENAL_CRONICA
              TABAQUISMO
              RESULTADO
Test mode:    10-fold cross-validation

=== Summary ===

Correctly Classified Instances      648100               92.0934 %
Incorrectly Classified Instances     55642                7.9066 %
Kappa statistic                          0.5343
Mean absolute error                      0.101
Root mean squared error                  0.2373
Relative absolute error                 53.3687 %
Root relative squared error             77.1552 %
Total Number of Instances           703742

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC
                 0.970    0.490    0.944      0.970    0.956      0.540
                 0.510    0.030    0.665      0.510    0.577      0.540
Weighted Avg.    0.921    0.442    0.914      0.921    0.916      0.540

=== Confusion Matrix ===

      a      b   <-- classified as
 610144  19154 |      a = No
  36488  37956 |      b = Si
```

Table 2 Model 1: Classification by deceased in Mexico

As can be seen in the Table, this model was evaluated with the cross-validation technique based on 10 partitions, so it is presumed that the model is effective in its use for prediction purposes. As an example, in Table 3, two of the more than 6,000 rules in the model are shown, which, in our consideration, have remarkable significance due in part to the number of cases involving.

ISSN-2531-2952

TIPO_PACIENTE = Ambulatorio AND NEUMONIA = No AND EDAD <= 55 AND RENAL_CRONICA = No AND DIABETES = No AND EPOC = No AND EDAD <= 43 AND INMUSUPR = No: No (295180.0/336.0)	INTUBADO = Si AND EDAD > 48 AND EDAD > 61 AND ENTIDAD_UM = Edo. de Mexico AND ASMA = No AND EPOC = No AND SEXO = Hombre: Si (632.0/56.0)

Table 3 Sample of two rulers in Model 1

In particular, the first rule in the previous Table involves 42% of the positive cases (295,180 out of 703,742 cases) with only 0.1% of misclassified cases. From this rule, it can be inferred that a person with COVID-19, without major diseases such as pneumonia, chronic kidney disease, diabetes and COPD, will get ahead of the disease as long as they do not exceed 43 years. In the case of the second rule, it refers to the death of men in a specific area of the country, the Edo. from Mexico. The rule indicates that when a patient (man) older than 48 years is intubated, his disease will be complicated until death, even if he does not have other conditions such as asthma or COPD. However, this rule has 9% misclassified cases.

On the other hand, a particular rule occurs when executing the Weka J48 classifier (algorithm C4.5) on the set of death cases, which as we know from a previous analysis corresponds to 74,444 cases, 47,767 men and 26,677 women. As expected, classification errors do not occur in the generated model. This is shown in Figure 1.

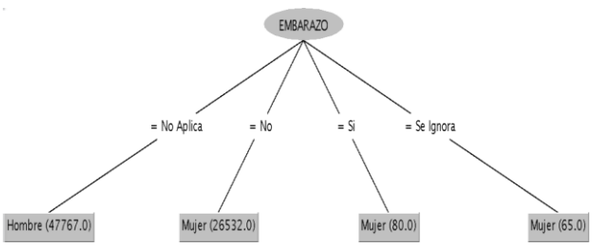
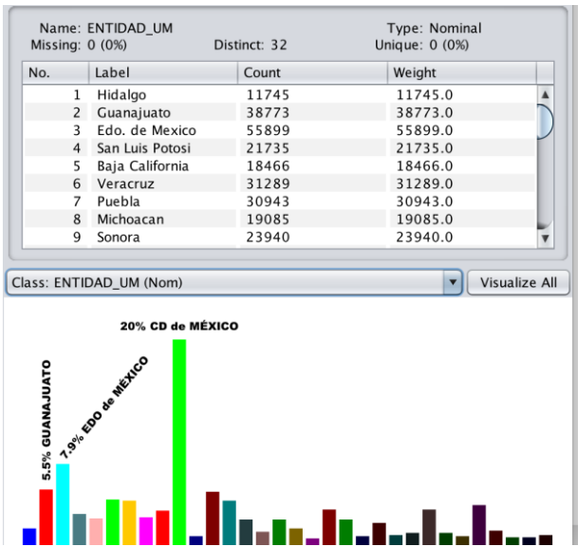


Figura 1 Tree generated from the deceased segment

In this case, despite being a 100% reliable model, the knowledge it represents is not very relevant, due to the fact that it is about knowledge that is already had, except for the breakdown of deaths in the case of women, making a classification between pregnant and non-pregnant, which, as can be seen, almost all deaths (99%) fall on non-pregnant women.

As has been seen, among the rules that resulted in the set of positive cases, there were rules associated with particular States, as was the case of a rule previously described for the State of Mexico. In this sense, it was considered convenient to also carry out an analysis locally, that is, by States. Thus, in Graphic 5, the segmentation of positive cases by State is shown as a starting point for the local analysis.



Graphic 5 Segmentation of positive cases by State

In this Graphic, the highest bar stands out with 20% of the cases, which corresponds to Mexico City; However, it is followed by the State of Mexico with 7.9% of the cases and the State of Guanajuato with 5.5% of the cases. This last case, that of the State of Guanajuato, draws particular attention because its population is considerably smaller than the population of other States such as Jalisco, Nuevo León and Veracruz, but the number of infections is higher than these States. Based on this observation, it was decided to take the State of Gto as the beginning of our local analysis.

In Table 4, the model generated by executing the J48 classifier is presented on the set of positive cases in the State of Guanajuato with respect to the death variable. This model, evaluated with the cross-validation technique based on 10 partitions, yielded 94% of correctly classified cases, therefore, like the model generated from positive cases throughout the country, it is considered effective in its use for prediction purposes. Thus, from this model, the rule shown in Figure 2, illustrated as a tree, was obtained, which is obviously highly significant in the left part of the tree as it involves 83% of all cases (32,193 of 38,773 cases) and a low percentage of misclassified cases (1.3%).

ISSN-2531-2952

```
=== Run information ===

Scheme:       weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:     200924COVID19 Guanajuato Positivos-weka.filters
Instances:    38773
Attributes:   16
              SEXO
              TIPO_PACIENTE
              FALLECIO
              INTUBADO
              NEUMONIA
              EDAD
              EMBARAZO
              DIABETES
              EPOC
              ASMA
              INMUSUPR
              HIPERTENSION
              CARDIOVASCULAR
              OBESIDAD
              RENAL_CRONICA
              TABAQUISMO
Test mode:    10-fold cross-validation

=== Summary ===

Correctly Classified Instances       36501               94.1403 %
Incorrectly Classified Instances      2272                5.8597 %
Kappa statistic                          0.4379
Mean absolute error                      0.0839
Root mean squared error                  0.2098
Relative absolute error                 63.177  %
Root relative squared error             81.4316 %
Total Number of Instances            38773

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC
                 0.986    0.642    0.952      0.986    0.969      0.462
                 0.358    0.014    0.669      0.358    0.466      0.462
Weighted Avg.    0.941    0.598    0.932      0.941    0.933      0.462

=== Confusion Matrix ===

     a     b   <-- classified as
 35510   491 |     a = No
  1781   991 |     b = Si
```

Table 4 Model 2: Classification by deceased in Gto.

```
=== Run information ===

Scheme:       weka.classifiers.rules.PART -C 0.25 -M 2
Relation:     200924COVID19 Guanajuato Positivos-weka.filters
Instances:    38773
Attributes:   16
              SEXO
              TIPO_PACIENTE
              FALLECIO
              INTUBADO
              NEUMONIA
              EDAD
              EMBARAZO
              DIABETES
              EPOC
              ASMA
              INMUSUPR
              HIPERTENSION
              CARDIOVASCULAR
              OBESIDAD
              RENAL_CRONICA
              TABAQUISMO
Test mode:    10-fold cross-validation

=== Summary ===

Correctly Classified Instances       36409               93.903  %
Incorrectly Classified Instances      2364                6.097  %
Kappa statistic                          0.4369
Mean absolute error                      0.0814
Root mean squared error                  0.2128
Relative absolute error                 61.2752 %
Root relative squared error             82.6083 %
Total Number of Instances            38773

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC
                 0.983    0.626    0.953      0.983    0.968      0.453
                 0.374    0.017    0.623      0.374    0.467      0.453
Weighted Avg.    0.939    0.583    0.930      0.939    0.932      0.453

=== Confusion Matrix ===

     a     b   <-- classified as
 35373   628 |     a = No
  1736  1036 |     b = Si
```

Table 5 Model 3: Classification by deceased in Gto.

According to the above, the rule in Figure 2 is categorical about what it implies in the left part of the tree, that is, in the State of Gto., An outpatient (INTUBADO = Not Applicable), without a pneumonia condition, you will not be at risk of death.

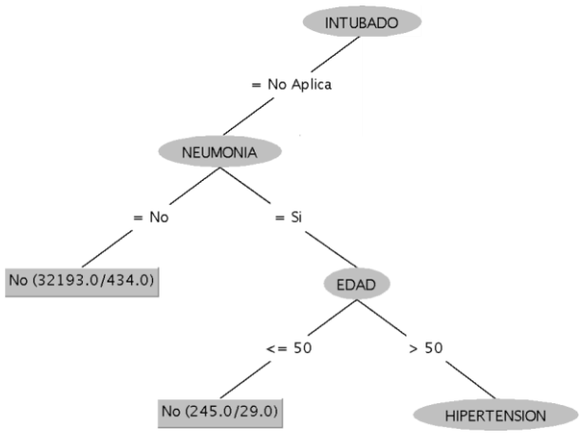


Figura 2 Best rule in Model 2

Another alternative model to the model in Table 4 was generated, with the PART classifier, which also contains (to a large extent) the previous rule, but fractioned and with slightly more specific information. This model is shown in Table 5, where it can be seen that it is only slightly less effective than the model in Table 4 in terms of classification (93.9% vs 94.1%).

The rules in sections (a), (b) and (c) in Table 6, as a whole, could be said to be largely equivalent to the rule in Figure 2, only that, as mentioned above, they provide great information additional. For example, the rule of subsection (a) adds that the person must not exceed 50 years, which dominates the condition of subsection (b), while the rule of subsection (c) adds that the person must be a woman who does not smoke and does not have immunosuppression, EOPC, or chronic kidney disease.

(a)	(b)
INTUBADO = No Aplica AND NEUMONIA = No AND EPOC = No AND EDAD <= 50: No (24198.0/91.0)	INTUBADO = No Aplica AND NEUMONIA = No AND EPOC = No AND EDAD <= 65: No (5723.0/144.0)
(c)	(d)
INTUBADO = No Aplica AND NEUMONIA = No AND SEXO = Mujer AND TABAQUISMO = No AND INMUSUPR = No AND RENAL_CRONICA = No AND EPOC = No: No (984.0/50.0)	INTUBADO = Si AND EDAD > 42 AND EPOC = No AND EDAD <= 80 AND TABAQUISMO = No AND DIABETES = Si AND INMUSUPR = No AND OBESIDAD = No: Si (136.0/8.0)

Table 6 Sample of four rulers in Model 3

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Regarding the rule in subsection (d), this refers to the imminent death of an intubated person when he presents the conditions listed in subsection.

Conclusions and future work

This article described the construction of different models to extract knowledge from the data published by the Federal Government of Mexico on the COVID-19 disease. The models were basically built as classification models, using the C4.5 algorithm, and evaluated with the cross-validation technique.

In the models, various rules were observed that to a large extent can be used to predict future scenarios about the evolution of the COVID-19 disease. However, as future work, it is being considered to build more robust prediction models by using artificial neural networks, following a three-phase methodology, similar to that described by Roy et al. (2020), on which there is already an important advance of the first phase, regarding data preparation, as described in this article.

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ISSN-2531-2952

Article **Journal of Applied Computing**
December 2020 Vol.4 No.15 26-35

Authentic-interactive activities to promote oral production on a virtual platform

Actividades interactivas-auténticas para promover la producción oral en una plataforma virtual

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DOI: 10.35429/JCA.2020.15.4.26. Received July 25, 2020; Accepted December 30, 2020

Abstract

Implementing learning or communicative strategies are not enough to develop oral production when learning English as a Foreign language; indeed, it is necessary to provide authentic activities that engage students in the act of speaking. The objective of this research is to know if the interactive activities operated in the Moodle platform promote oral production and identify the possible association between their scores from the instructional design and their speaking level from a standardized exam. For this, a longitudinal quantitative approach was carried out during spring 2020 in the Teaching English Bachelor at BUAP, having a sample of 20 subjects. The results demonstrated that the use of authentic-interactive activities improved the students' speaking competence significantly. Furthermore, this study pretends to contribute with useful theoretical information for teachers and students who want to select appropriate tasks to improve this competence. It is essential to clarify that this is an innovative study since it promotes the use of activities and strategies mediated by technology asynchronously and synchronously, which are flexible and suitable for students' needs in times of contingence.

Authentic-interactive activities, Oral production, Virtual environment

Resumen

Implementar estrategias de aprendizaje o comunicativas no es suficiente para desarrollar la producción oral al aprender inglés como lengua extranjera; de hecho, es necesario aplicar actividades auténticas que involucren a los estudiantes en el acto de hablar. El objetivo de esta investigación es conocer si las actividades interactivas operables en la plataforma Moodle promueven la producción oral e identificar la posible asociación entre sus calificaciones del diseño instruccional y su nivel de habla de un examen estandarizado. Para ello, se realizó un estudio cuantitativo longitudinal durante la primavera de 2020 en la Licenciatura de la Enseñanza del Inglés de la BUAP, teniendo una muestra de 20 sujetos. Los resultados demostraron que el uso de actividades interactivas auténticas mejoró significativamente la competencia oral de los estudiantes. Además, este estudio pretende aportar información teórica útil para profesores y estudiantes que quieran seleccionar tareas adecuadas para mejorar esta competencia. Es fundamental aclarar que se trata de un estudio innovador ya que promueve el uso de actividades y estrategias mediadas por tecnología de forma asincrónica y sincrónica, que son flexibles y adecuadas a las necesidades de los estudiantes en tiempos de contingencia.

Actividades auténticas-interactivas, Producción oral, Entorno virtual

Citation: FLORES-GONZÁLEZ, Norma. Authentic-interactive activities to promote oral production on a virtual platform. Journal of Applied Computing. 2020. 4-15:26-35.

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Introduction

The necessity of learning English as a foreign language is increasing in the Mexican educational field, especially in the academic one. In that attempt, students are supposed to learn how to write, listen, read, and speak it to use the language as a way to convey messages. However, the last skill represents an obstacle for the majority of learners who struggle with different vicissitudes such as pronounce isolated words, phrases, or disconnected sentences getting poor oral production, and they attribute it to their lack of communication and learning strategies, vocabulary, and practice. That is why the present research is important because it could offer some alternatives to avoid those obstacles. At this point, there are many studies in the state of the art that propose different means to improve oral production, which include learning and communication strategies, techniques, approaches, methods, or activities that promote that production, among others in on-site spaces. Nonetheless, what could teachers do when the development of such a skill has to be outside the classroom, in a non-native context, and under virtual learning due to current circumstances?

Taking into account the situation described above, the objective of this study is to know if an instructional design with interactive activities operated in the Moodle platform promotes oral production and identify the possible association between subjects' scores from that instructional design and their speaking level from a standardized test. For accomplishing it, two research questions will guide the research: Do authentic-interactive activities from the instructional design promote subjects' oral production?

Is there a possible association between the subjects' scores from the instructional design and their oral production level from a standardized exam?

Now, it is essential to define some key concepts to frame the research theoretically.

Literature review

Over the years, speaking has been considered a difficult skill to instill in students, mainly because of the lack of situations where they recognize its essential function like in meaningful tasks, real and immediate context for social interactions. As Bygate (1987, p. 1) mentions, "our learners often need to be able to speak with confidence in order to carry out many of their most basic transactions. It is the skill by which they are most frequently judge, and through which they make or lose friends".

Oral production

For effective communication between learners, it is crucial to provide them with the necessary accurate vocabulary, grammatical structures, and in general, suitable input.

Besides, when students are in the process of learning a foreign language, they need to have activities where communicative competence takes place; otherwise, they will never develop their speaking skills.

Communicative competence is a multifaceted concept, which regarding Savignon, as cited in Gónzalez (2008, p. 8), "depends on the negotiation of meaning". Then, its success is directly related to the speakers' cooperation and interests. That is why it is not simple; it implies more than generating utterances in isolation without counting on a context, social rules, or speakers' background. On the contrary, those speeches must convey accurate sense and meaning so that the receptor could comprehend the intended messages (Méndez, 2017).

Moreover, there is a big difference between speaking and oral skills. The former are students' drills according to pre-fixed conversation models, and the latter is a process where both listening and speaking must interact themselves to have successful communication between the speaker and receptor by alternating their roles respecting social and interactional rules.

ISSN-2531-2952

In speaking, there are two processes. According to Saville-Troike, the top-down looks for the handling of the topic as well as cultural knowledge. On the contrary, "The language knowledge involved in bottom-up processes for speech production includes appropriate vocabulary, features of pronunciation, grammatical patterns…" (2012, p. 175).

Strategies to develop oral production

In the educational field, the term strategy seems to have two connotations. The first refers to the means used to achieve meta-cognition in language learning; that is, learn and evaluate the process, often called learning strategy (LS). The second is associated with its use in a conversation to fix the communication, called communication strategy (CS). For that reason, different studies state the significance of teaching both to foster oral production.

On the one hand, for Chamot (2004, p. 1), language learning strategies are "the conscious thoughts and actions that learners take in order to achieve a learning goal". Besides, for Weinstein, Husman & Dierking (2000: 727), "learning strategies include any thoughts, behaviours, beliefs or emotions that facilitate the acquisition, understanding or later transfer of new knowledge and skills".

On the other hand, communication strategies are directly related to oral communication, and one of the first researchers to identify them was Varadi in the 70s.

Taking into account Bialystok (1990: 138), a CS is "the dynamic interaction of the components of language processing that balance each other in their level of involvement to meet tasks demands".

Different authors have researched learning strategies as Takeuchi, 1993; Green & Oxford, 1995; Cohen, 1998; Chamot et al., 1999 or communication strategies like Tarone, 1977; Bialystok, 1990; Poulisse, 1993; Yule & Tarone, 1990; Saville-Troike, 2012, Flores-González et al., 2019).

However, the use of strategies does not ensure the development of oral competence in students, and some studies (Grenfell & Harris, 1999; Macaro, 2006; Tragant & Victori, 2006) point out that. Besides, Vann and Abraham (1990) figured out in a study that both high and low proficient learners used a variety of learning strategies in their learning process, but the key difference was how they used them with the activities.

Authentic activities

Strategies by itself do not promote oral production; indeed, original activities are essential to engage learners in meaningful communicative exchanges. However, activities will be considered as authentic only if they face students in real situations where natural and spontaneous performances in formal and informal social contexts take place. In this way, these type of activities could overcome learners' feelings regarding academic tasks, which according to their perceptions, they are not focused on daily life. They seem to be for different contexts that are demotivating as they do not identify the usefulness of what they learn. Therefore, that learning is not very significant due to its limitations: use only in classrooms and lack of a link between their previous and new knowledge.

Some of the most outstanding characteristics of authentic activities are:

Features	Authors
They engage students in collaborative work.	(Gordon, 1998)
Authentic activities in meaningful and real situations.	(Lebow & Wager, 1994; Flores-González, et al., 2018)
Authentic activities focus on the task from diverse viewpoints through an assortment of resources.	(Sternberg et al., 1993; Bransford, Vye et al., 1990)
They foster critical and reflective thinking.	(Young, 1993)
The design of the activity, as well as its objectives, match with the evaluation process.	(Herrington & Herrington, 1998)
As they are integrative activities, investigative skills and time are required to carry them out.	(Bransford, Vye et al., 1990; Lebow & Wager, 1994)

Tabla 1 Features of an authentic task

ISSN-2531-2952

Furthermore, if such authentic activities are implemented in a virtual system, key elements are required for its proper functioning and purpose. They deal with the teacher's role to design, implement, and monitor the instructional design and students' roles to work individually and collaboratively in it.

Interactivite activies

Interaction is the scenario where students show what they know of a language (grammar, vocabulary, linguistic competence, and performance) and improve their oral production. Thus, said scenario must be a motivating, trustworthy, and friendly atmosphere for the students, without causing fear to speak and interacting with another as well as providing authentic-interactive activities that hook them in communicative purposes with effective language learning in and outside classrooms.

At this point, task-based learning allows developing communicative tasks to interact in real situations collaboratively, which fosters practicing, developing discursive strategies, and critically providing feedback to the rest of the speakers.

Besides, those types of tasks have specific aims like obtaining information, discussions about interesting topics, and learning about the culture, which according to Moss and Ross-Feldman (2003), provide meaningful insight in an active-learning context. All in all, such activities depend on the creativity of the teachers. However, citing Csikszentmihalyi (2013), some aspects are needed for that objective like

> Preparation: Arousing curiosity of a problematic situation.
> Incubation: Ideas fly below the threshold of consciousness.
> Insight: The moment when the puzzle starts to fall together.
> Evaluation: Deciding if the insight is valuable and worth pursuing.
> Elaboration: Translating the insight into its final work (p. 79).

The success or failure of these types of activities depends on the level of interaction in such virtual environments and the interactive technology that mediates the learning process. In this case, such technology consists of any tool or medium that helps students interact with their peers or with online materials.

Taking into account the pandemic and confinement that humanity is facing now, education has evolved from traditional to virtual classrooms, which is causing problems to students ad teachers due to their lack of strategies and ways to implement it. Thus, the following lines describe synchronous and asynchronous activities as insight for their inclusion in virtual environments.

Synchronous activities. These types of activities take place in real-time; then, the speaker and listener must be present and interact by video or audio conferencing with the help of some digital tools or applications.

Some advantages of asynchronous activities are the overcome of the learning isolation process and live teaching sessions.

Asynchronous activities. They are time-independent activities that promote learning at the students' own pace according to their needs, times, and objectives. This interaction occurs by using asynchronous tools such as the discussion forums, e-mails, and some applications that allow them to record and host said participation on a platform or virtual space, so their audience listens to it at any time.

Students who work on this modality should be motivated and have clear objectives since they do activities on their own with online explanations provided by the online course and their autonomous learning.

Some examples of synchronous activities are life-classes with a pre-determined objective, video recording to have discussions or debates, as well as platforms for meetings, question-answer sessions, and others. Asynchronous examples are quizzes, pre-recorded videos, integrated tasks, extra exercises with feedback through forums, or practice through blogs and wikis.

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Ideally, virtual courses should be balanced and include both types of activities; in that way, teachers and students take advantage of the benefits of each one. On the one hand, learners work at their own pace in a flexible environment regarding time and space, have immediate help from their facilitator, work individually and collaboratively with authentic-interactive activities developing their listening, reading, writing, and speaking skills autonomously to some extend. On the other hand, teachers offer students active and innovative learning by using different delivered formats as well as learning methods, which could fit learning styles suitably.

Methodology

Different studies have focussed on the use of technology for teaching and learning process with a variety of methodologies and scopes such Flores-González's research (2019), which proposed the use of blended-learning modality to promote extensive reading; Felix's study (2001) that presents perspectives on the Web as a medium of language instruction or Ushida (2005) who searches about motivation and attitudes towards an online language course context. Besides, Sagarra and Zapata (2008) state significant learning when combining instructional courses with CALL, or Wang and Wang (2010), who point out positive students' perception in a CALL course implementation. Finally, Flores-González, and Fernandez-Crispín (2019), whose study shows how strategies mediated by technology promote meaningful learning.

For the present research, a longitudinal quantitative approach was carried out during spring 2020 in the Teaching English Bachelor at Benemérita Universidad Autónoma de Puebla. The selection of this methodology was due to its advantages regarding measuring (Leedy & Ormrod, 2013) the same phenomenon in different times repeatedly by using the same method that in this case was done by measuring subjects' speaking level with checklists and rubrics during the instructional design to analyze quantitative data and changes during four months. Then, those results were compared with the speaking scores gotten from a standardized test. Besides, it also allows the researcher to describe the situation (Cresswell, 2005) and identify possible relationships between variables.

Sample.

It was randomly selected and composed of 20 subjects who shared common characteristics like: have synchronous sessions 4 hours a week and work independently on the platform at least 10 hours a week. All of them accredited B1 and B1+ in speaking.

The data gathered from the subjects' scores of the instructional design, which lasted four months, were analyzed according to the model of analysis below.

Research question 1	**Indicator**	
Do authentic-interactive activities from the instructional design promote subjects' oral production?	Grades got from the instructional design taking into account synchronous and asynchronous authentic-interactive activities in the Moodle platform, which were graded based on rubrics and checklists.	
Research question 2	**Variables**	
Is there a possible association between the subjects' scores from the instructional design and their oral production level from a standardized exam?	Variable 1 General subjects' scores from the instructional design based on authentic-interactive activities	Variable 2 Subjects' scores from a standardized exam

Table 2 Model of analysis

Results

RQ1. Do authentic-interactive activities from the instructional design promote subjects' oral production?

The instructional design followed the ADDIE model for e-learning, whose acronym stands for analysis, design, development, implementation, and evaluation that are its five stages.

Regarding the content of the course, it comprises both synchronous and asynchronous authentic-interactive activities according to competencies and descriptors to reach a B2 level in speaking, as shown in the following tables.

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Synchronous authentic-interactive activities	
Before the speech activity (engagement into the topic)	Rank ideas and brainstorming
During the speech activity	Activities based on role-plays and songs
	Immersive environments according to a pre-fixed topic
After the speech activity	Summarizing
	Question-answer set

Table 3 Synchronous authentic-interactive activities

Asynchronous authentic-interactive activities	
1.	Argumenting by using Voxopop
2.	Explaining points of view in a debate by sing Screencast-o-matic
3.	Predicting consequences, causes, or hypothetical situations with Voicethread
4.	Defending points of view with Atto

Table 4 Asynchronous authentic-interactive activities

These activities comprised oral production done from texts or videos and carried out with digital tools in the Moodle platform.

During the course, subjects actively engaged in speeches as members of the e-class using their linguistic competence and performance. Their practice helps them not only to reinforce grammatical structures in context and put them in their long-term memory but also to learn new vocabulary, phrases, and idiomatic expressions.

Another vital aspect that will contribute to teachers' practices citing Kelchtermans (2009) was that during the course and thanks to the type of activities, the facilitator could identify subjects' limited language and implement extra-activities to correct them.

In the case of the synchronic sessions, preparing students by getting background information for the topic to be discussed from their e-classmates was an ad hoc activity and stage (rank ideas and brainstorming activities). Then, roles-plays and songs, as well as immersive activities, fostered students' production in artificial similar real-world, which motivated them to speak naturally and spontaneously without fear of committing grammatical mistakes or mispronunciation.

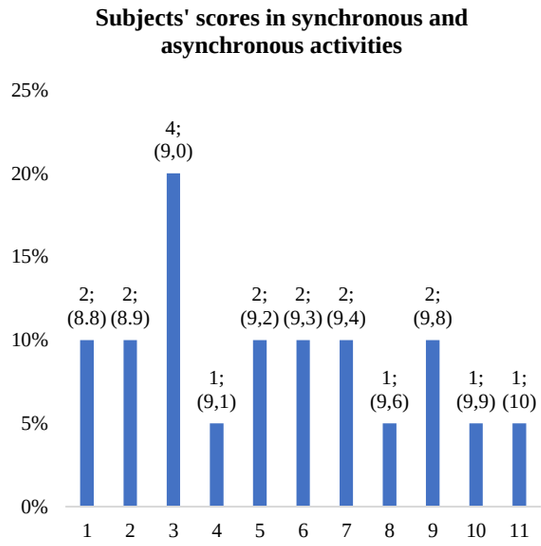
The activities to closure the synchronous stage allowed learners to reflect about their content in terms of what they learn, how to join or relate the new information with their previous one, learn about cultural features and identify e-classmates interest and likes, which develop a sense of academic community to work on research activities or projects apart from this course.

Using applications, digital tools, and social networking sites lets teachers spread the learning process beyond traditional classrooms (Flores-González, *et al*., 2019).

In the case of asynchronous activities, the use of applications and digital tools did motivate them to speak and participate by expressing their points of view so that their e-classmates provided feedback to their answers through forums or recordings.

Besides, the percentage of subjects' participation increased in this modality in comparison to traditional classrooms. Possibly, due to the freedom and flexibility of working at any place and time.

The following graphic presents the subjects' scores from the instructional design.



Graphic 1 Subjects' scores

ISSN-2531-2952

As shown in the graphic, the scores demonstrate that authentic-interactive activities promoted subjects' oral production to reach a different level of command mainly based on two reasons: competencies and descriptors of B2 included in the design, and their actual proficiency level at the beginning of the course (B1 and $B1^{+}$).

During this course, they denoted a quite broad language level to accomplish clear and accurate descriptions with standard rhythm, complex grammatical structures without mistakes that causing misunderstanding or finishing the conversation. They also monitored their participation and did corrections by themselves when necessary. In general, they carried out the following:

- Give detailed explanations and a string of reasoned arguments to defend their position towards a topic.
- Analyze a topic according to the advantages and disadvantages it could provide.
- Speculate possible causes and effects or relationships of a given topic.
- Have successful participation in formal and informal speeches by arguing, explaining, showing pros and cons, evaluating possible solutions, confirming or refuting hypothetical situations.
- Emit respectful comments by supporting their speech with their experience, facts, and authors.
- Use linguistic competencies and conversational strategies to keep on in a conversation.

In summary, subjects from this study should be on a B2 level or more because they could manage themselves adequately in their course, as mentioned before.

However, the conclusion above needs some corroboration. For that reason, subjects' scores were associated with their speaking scores from a standardized exam to answer the second research question of the present study.

RQ2. Is there an association between subjects' scores from the instructional design and their speaking level from a standardized exam?

Subjects	Variable 1	Variable 2
1.	8.8	B2
2.	8.8	B2
3.	8.9	B2
4.	8.9	B2
5.	9	B2
6.	9	B2
7.	9	B2
8.	9	B2
9.	9.1	B2
10.	9.2	B2
11.	9.2	B2
12.	9.3	$B2^{+}$
13.	9.3	$B2^{+}$
14.	9.4	$B2^{+}$
15.	9.4	$B2^{+}$
16.	9.6	$B2^{+}$
17.	9.8	$B2^{+}$
18.	9.8	$B2^{+}$
19.	9.9	$B2^{+}$
20.	10	$B2^{+}$

Table 5 Association of the subjects' scores from the instructional design with the standardized exam

Based on the findings above, there is an association between the scores from the instructional course and subjects' proficiency level; it is evident. Indeed, the students who got a higher grade in their virtual classes did the same in their proficiency exam.

Thus, the study confirms both research questions and concludes that the proposal consisting of using authentic-interactive activities to foster oral production guides to reach a higher level.

Conclusions

First of all, the findings show a clear improvement of subjects' speaking proficiency level, and thus, linguistic knowledge.

It also provides information for teachers to improve their pedagogical practice in virtual environments to work with oral production or even to adopt this methodology and proposal to foster other skills or sub-skill.

ISSN-2531-2952

Besides, the use of authentic-interactive activities proved an alternative to develop oral production, which constitutes a high possibility of teaching in these times when education has migrated to virtual modalities.

By using those said activities, subjects improved their speaking proficiency level, showing acceptable parameters of interaction and performance not only in the instructional course but also in a standardized exam.

Furthermore, subjects develop a sense of virtual community where the average participation was high and characterized by their motivation to speak more naturally and spontaneously as well as learn from others not only content but also culture and social rules to interact without that typical fear and lack of motivation that is common in traditional classrooms.

The demands and requirements from the authentic-interactive activities pushed learners to be engaged in speeches with enough information to discuss and keep their rhythm in clear, accurate, and meaningful turn-takings.

Another key feature is that subjects did not demonstrate being under pressure or stressed to perform oral productions, which is an essential factor for the teaching-learning process.

Finally, it is worth mentioning that one possibility to enrich this research is by analyzing it qualitatively to have a broader scope on perceptions towards the instructional course, and in that way, taking some decisions regarding its design, re-designed, implementation, and evaluation.

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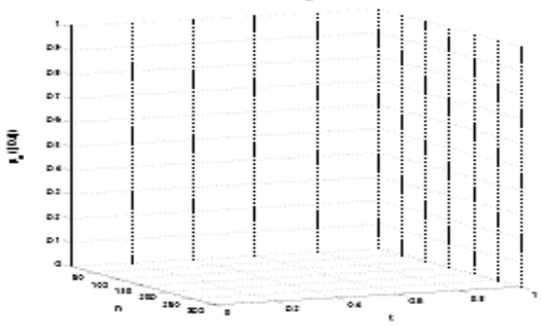

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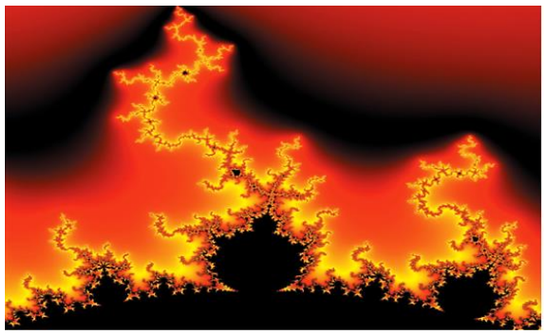

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