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Virtual laboratory as a strategy in distance education for programming in the face of COVID-19

Laboratorio virtual como estrategia en la educación a distancia de la programación ante la COVID-19

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Abstract

Nowadays we live a great change in all areas, in all areas, both labour and academic, since with the arrival of the new disease known as COVID-19, all people and governments have been in the need to isolate themselves in their homes to avoid infection. This has caused the country's universities to opt for new ways of teaching remotely, adapting learning environments to the new digital era. This paper proposes a free web tool called GDB Online, to be used as a virtual laboratory in Higher Education Programming practices. The results of a cohort study of two groups of students of the bachelor's degree in Energy Engineering of the Programming Learning Unit, from different cycles; one group using the GDB Online tool and the other without using it, are presented. The statistical results and the mathematical modelling show a positive scholastic achievement in the group that used the tool over the group that did not use it.

Programming, Virtual laboratory, COVID-19, Virtual education

Resumen

En la actualidad vivimos un gran cambio en todos los ámbitos, tanto laborales como académicos, debido a que con la llegada de la nueva enfermedad conocida como COVID-19, todas las personas y gobiernos se han visto en la necesidad de aislarse en sus hogares para no contagiarse. Esto ha provocado que las universidades del país opten por nuevas formas de enseñanza de forma remota, adaptando los entornos de aprendizaje a la nueva era digital. En el presente documento se propone una herramienta web gratuita llamada GDB Online, para ser empleada como laboratorio virtual en prácticas de Programación de Educación Superior. Se presentan los resultados de un estudio tipo cohorte de dos grupos de alumnos de la Licenciatura en Ingeniería en Energía de la Unidad de Aprendizaje de Programación, de ciclos distintos; un grupo haciendo uso de la herramienta GDB Online y otro sin emplearla. Los resultados estadísticos y el modelado matemático muestran un aprovechamiento escolar positivo en el grupo que hizo uso de la herramienta sobre el que no lo hizo.

Programación, Laboratorio virtual, COVID-19, Educación virtual

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Introduction

Faced with the contingency produced by the SARS-CoV-2 pandemic (Severe Acute Respiratory Syndrome Coronavirus 2), coronavirus type 2 of severe acute respiratory syndrome, which causes the disease known as COVID-19, all aspects of our society have suffered alterations in its development, higher education was no exception, where Mexican institutions chose to implement new strategies to continue with the development of their activities. the "Universidad Autónoma de Campeche" (UACAM) is Mexico's public university, which was founded on August 7, 1965.

In response to this contingency, UACAM, in line with the sanitary measures issued by the authorities at all levels of government, suspended work on March 23, 2020 and began preparing an alternate work program to guarantee the continuity of school activities. Following the provisions of the educational authorities, it issued a communiqué on April 29, 2020, to announce that classes would resume virtually as of May 6 to conclude the 2019-2020 F2 school year, which had been suspended in its second partial. In order to continue with the school activities of the semester in question, the university community of the UACAM continued working virtually and academic activities were developed through the institutional platform of the Google Suite, Classroom.

The Faculty of Engineering of the UACAM issued a document entitled "Suggestions for remote teaching strategies in the COVID-19 contingency, for grading the second partial", in order to provide technological strategies to develop academic work from home. In this document it is highlighted that the thematic contents would not change, emphasizing the use of information and communication technologies to achieve the learning process outside the physical classroom of the institution. (FDI-UAC, 2020, April 29).

Derived from the above, the researchers formulated a didactic strategy to teach the thematic contents of the second partial of the Programming Learning Unit of the Bachelor's Degree in Energy Engineering, for second semester students.

At the end of the school year, a recovery period was offered to students who for some reason were unable to complete the activities on the dates originally stipulated.

Since the COVID-19 contingency was extended, classes remained virtual during the 2020-2021 F1 (September-December) and 2020-2021 F2 (January-June) school years.

With the experiences lived in the 2019-2020 F2 school year, UACAM for the 2020-2021 F1 and 2020-2021 F2 school years issued a document entitled: "Operating Policies during remote teaching for continuity of academic service for the 2020-2021 school year", with the premise of safeguarding the life and health of people, taking into account health recommendations. (UAC, December 17, 2020).

All of the above in accordance with the General Student Regulations of the Autonomous University of Campeche, which states in its: "CHAPTER VI OF THE MODALITIES. Article 7. The modalities are environments in which the teaching and learning process is developed, and may be face-to-face and non-face-to-face. The learning environment is the space in which students and academics interrelate to develop knowledge through teaching and learning strategies with the support of educational materials and resources. The learning environment can be:

- Face-to-face: It is characterized because the relationship between the student and the academic is face-to-face in a predetermined physical space. It is similar to the school-based modality; and

- Non-presential: It is characterized because the relationship between student and academic is mediated by physical distance and is predominantly asynchronous. It is equated to the non-school-based, semi-school-based, distance, virtual or mixed modality." (UAC, 2009, July 8)

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Therefore, the mixed modality has synchronous or face-to-face (virtual or physical) and non-face-to-face (asynchronous) activities with a structure of interaction established by the Institution and its actors and conducted by the "Programa de Unidad de Aprendizaje" (PUA) promoting the appropriate application of knowledge for the acquisition of knowledge and competencies of students.

This document establishes the requirement to maintain 50% to 70% of the hours/week/month established in the PUA in a synchronous manner, within the schedules defined in the School Administration and Services System. In addition, it mentions that laboratory practices, clinics, site visits, companies or institutions is not feasible in face-to-face format, audiovisual tools or simulators previously agreed by the Teachers Academy should be used for the development of skills defined in the Learning Units. (UAC, 2020, August 28).

According to what is established in the "Operation Policies during remote teaching for continuity of academic service for the 2020-2021 school cycle", the researchers generated a strategy for the execution of the laboratory practices of the Learning Unit Programming Learning Unit of the Bachelor's Degree in Energy Engineering, for second semester students, of the 2020-2021 F2 school cycle, with the use of the GBD-Online tool.

Programming can be defined as the process of creating computer programs which is nothing more than an explanation to the computer of what, in what form and how to reach the user, it can also be defined as the art of translating the desires of a person into the language of the machine so that it performs a specific function. (Castells & Calviño, 2013).

The skills to be developed in students, take theory to practice, for this in the Programming Learning Unit it is necessary to have spaces (physical or virtual) that allow students the execution of programs with the support of teachers.

A virtual laboratory is a computer site that simulates a learning situation commonly performed in a physical space called a laboratory (Nájera & Estrada, 2007).

Virtual laboratories offer multiple benefits, including:

- Web-based control increases the technical training of users and provides practical knowledge from a distance.
- Web interfaces enable data acquisition.
- Interactive technical support, deployment and real-time result analysis.
- Collaboration with other members.
- Specialized user training in a highly specialized research environment.

A Virtual Laboratory for the programming area integrates an editor and a compiler available via web, closing the difficulties of access to physical laboratories to which students must access, allowing asynchronous access to the environment by different users, as a space for practice and feedback on the progress of their solution against the test cases. (Nájera & Estrada, 2007).

A Virtual Laboratory is an application that has a perceptible impact on the interaction between students and teacher. So far, the possibility of having an automated support in aspects of compilation, delivery of exception messages with higher semantic content, delivery of time computations in addition to a logical decision about the fulfillment of the objective of the problem, is not possible; therefore, it is essential the advice of all the above by a (human) teacher and thus favor the learning of programming.

GBD

The standard debugger for GNU known as GDB or GNU Debugger was created in 1986 by GPL, this debugger works with several programming languages such as C, C++ and Fortran, among others. GDB also offers a compiler, which allows us to create and execute programs. (Moreno Moll, 2002)

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A compiler can be understood as that program or software that is capable of translating another program that has been written in a high-level programming language, into a machine language that is low-level. (Alfonseca *et al.*, 2002)

GDB has two modes of use:

1. Desktop: This compiler is portable and can be used in several Unix platforms, in spite of not containing its own Graphical User Interface, it is very comfortable to handle by command lines, this is an advantage for the new students, since it offers them a better handling and control of the command lines in addition that they learn not to depend on a GUI to program. (Moreno Moll, 2002).

However, it must be installed on a Debian-based Linux distribution (e.g. Ubuntu, Mint, etc.). To download the GDB source code and subsequently compile and install it can be found at the following address http://ftp.gnu.org/gnu/gdb/.

2. Online: In its online mode, the GDB allows us to link an email account, Facebook or Git to save our programs and specially to share them, thus making collaboration easier. As it is a web system and allows file sharing, it is not necessary to meet physically among developers, representing a strategy with great value in the COVID-19 contingency. To access the GDB Online just place the following link in the address bar of a browser: https://www.onlinegdb.com/

To save and/or share future projects it is necessary to register with an email account and through Facebook or a Git account. Figure 1 shows the toolbar with the functions that can be performed in GDB Online, some of these functions are to create a new project, create a file or upload it from the PC, save and even share via link.

Figure 1 Description of the functions offered by GDB Online
Source: Prepared by the authors

DEV C++

It is an integrated development environment for writing and compiling code in the C/C++ language, which requires installation on a PC. It takes up very little space on the hard disk, which makes it ideal for creating small programs in which it is only necessary to demonstrate the use of control structures and data structures, these applications can be quickly compiled and executed in console form.

Methodology

Taking into account the various classifications on the types of research studies, the present work was carried out as follows:

1) According to the intervention of the researcher on the studied phenomenon, it is observational, its main objective is to "observe and record" those events of interest for the study, without altering or intervening in their natural course.

2) According to the source of data collection, it is documentary, because it was collected at the place where the phenomenon occurred.

3) According to the purpose of the research, it is applied, since it offers elements to implement a technology and solve a problem on the remote education of programming.

4) According to the number of occasions in which the data are collected, it is transversal, because they are collected in a single moment, in a single time.

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5) According to the level of depth of the planned search for the knowledge to be obtained, it is of the comparative descriptive type, since it describes the differences in the variables of two study groups.

6) Finally, according to the sense of the explanation of the phenomenon, it is of the case-control (or retrospective) type, because two groups will be studied, a case group (with the variable to be tested) and a control group (without the variable to be tested). (Rodríguez & Cabrera, 2007)

Population to be observed

GROUP 1. 25 students of the Bachelor's Degree in Energy Engineering, belonging to the second semester "A", who took the Programming Learning Unit in the 2019-2020 F2 school year.
GROUP 2. 24 students of the Bachelor's Degree in Energy Engineering, belonging to the second semester "A", who took the Programming Learning Unit in the 2020-2021 F2 school year.

Time Period to be Evaluated

The results of the second partial of the school cycles 2019-2020 F2 and 2020-2021 F2, due to the fact that these are the periods in which the conditions of GROUPS 1 and 2 coincide.

Only the second partial is considered because only this was taught remotely in GROUP 1, since for the first partial there was no contingency for COVID-19, therefore, it was taught in person.

GROUP 2, the entire 2020-2021 F2 school year, was taught in a retaught manner according to the institutional policies mentioned above.

Variable

The variable to be observed is the Virtual Laboratory in the development of the practices designed for the second partial of the Programming Learning Unit.

Figures 2 and 3 show the presence of the variable in each GROUP.

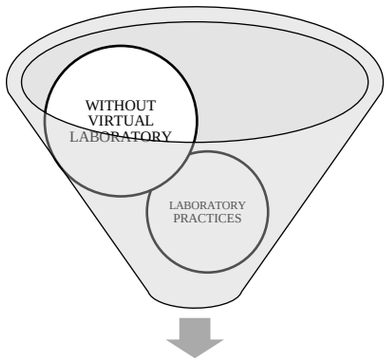

Figure 2 Conditions Group 1. School achievement without virtual laboratory
Source: Prepared by the authors

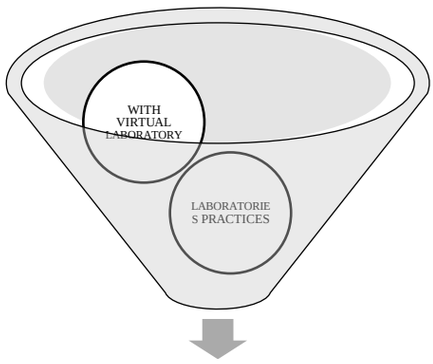

Figure 3 Conditions Group 2. School achievement with virtual laboratory
Source: Prepared by the authors

Educational conditions

The topics developed in the second partial of the Programming Learning Unit Program, which were approved by the Academy of Teachers of the Bachelor's Degree in Energy for the school Cycles 2019-2020 F2 and 2020-2021 F2 are the following:

1. Selective Structures

2. Iterators

3. One-dimensional and two-dimensional arrays.

For the development of skills in the above mentioned topics, 5 practices were developed, whose instructions are detailed in a PDF and/or video file and are shared with the students via the Educational Platform, with the corresponding evaluation criteria, through a Rubric.

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The practices developed in groups 1 and 2 were the following:

Practice 1.- Selective Structures

Practice 2.- Switch and Do While

Practice 3.- Iterators

Practice 4.- Array Arrays

Practice 5.- Bidimensional Arrays

Programming tool

Group 1.- The practices of the first partial were carried out in the computer laboratory of the Faculty, where each student had a computer with the DEV C++ compiler installed, with which they became familiar.

For the second partial the synchronous classes were carried out in the Google Meet application and the compiler used was DEV C++, which each student and the teacher had to have installed in their computers. This meant that each student, when having a difficulty, had to share their screen (through the Meet application), so that the teacher or teammates could observe the development and help in the solution, as shown in Figure 4.

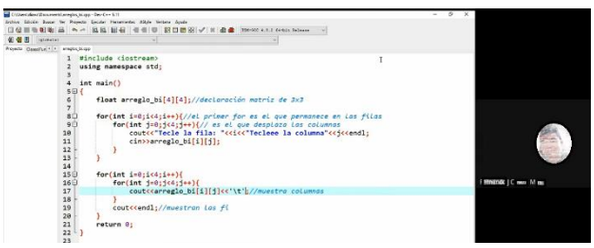

Figure 4 Student sharing his screen in the Meet application, to verify his code using DEVC++
Source: Prepared by the author

Group 2. - During the second partial, the classes and practices were carried out in the online compiler called GDB (See Figure 5), which requires an Internet browser and has the option of sharing the code through a URL.

Therefore, in the development of the practices in a synchronous way with the Meet application, when a student had some difficulty in the development of the practice, he only shared the link with the teacher, through the chat or with his teammates so that they could collaboratively find the solution. Virtualizing the dynamics of the on-site computer lab, as shown in Figure 6.

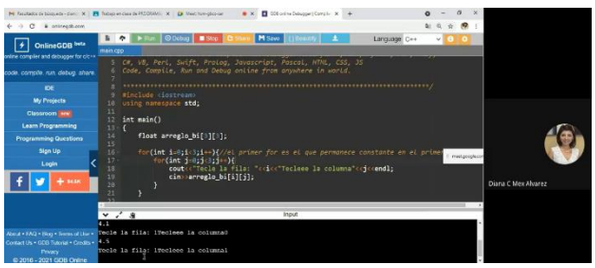

Figure 5 Use of GDB Online in the Synchronous Programming Classroom
Source: Prepared by the authors

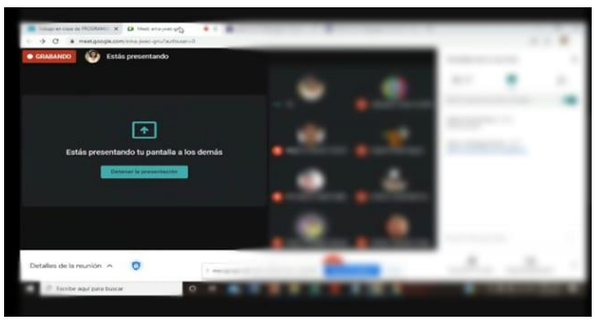

Figure 6 Monitored students' practices synchronously with GDB Online as a Virtual Lab
Source: Prepared by the authors

Results

In the school cycle 2019-2020 F2, a total of 25 students were enrolled in the Programming Learning Unit, who used the DEV C++ as compiler of the 5 practices corresponding to the second partial and the Meet application as a means of synchronous communication. The grades were variable and their frequencies are presented in Graphic 1, through a Histogram, where it can be seen that 4 students had a grade of 0, 4 students 9.8, 4 students 10, then 2 students had a grade of 9.4, 2 students 9.9 and the remaining 9 students had grades of 8.1, 8.3, 8.4, 8.7, 8.9, 9.1, 9.2, 9.3 and 9.7, each one.

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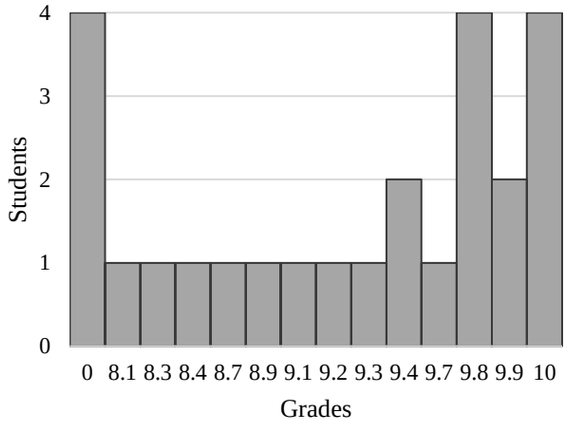
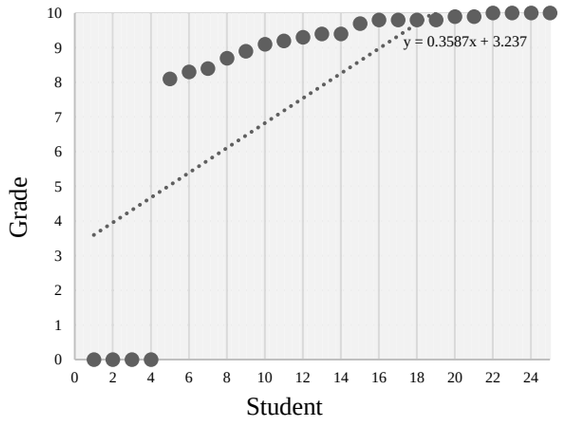


Graphic 1 Histogram of grades obtained by GROUP 1

The average academic achievement of GROUP 1 was 7.9, 21 students with a passing grade (84% of the total) and 4 students with a failing grade (16%).

Graphic 2 presents the scatter plot of the 25 grades and the linear regression that represents them in order to analyze the mathematical model of the equation of the line (1).

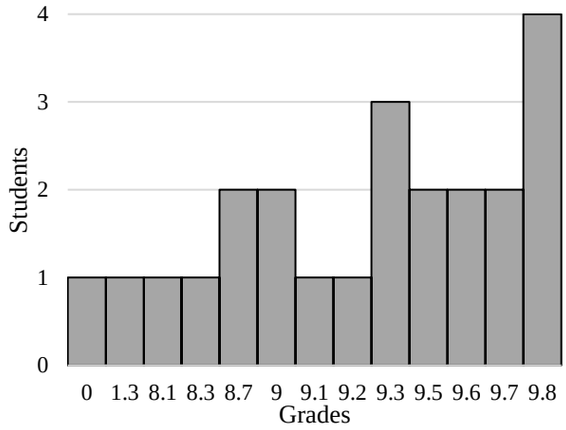


Graphic 2 Regression dispersion Linear ratings for group 1

The equation of the line (1) has a slope m of 0.3587, which when calculating its arc tangent gives us 0.344404254 radians, which is equivalent to a slope angle of 19.7329102 degrees.

On the other hand, in school year 2020-2021 Phase 2, the number of students enrolled was 24, who used the GDB Online tool as a compiler of the 5 practices corresponding to the second partial and the Meet application as a means of synchronous communication.

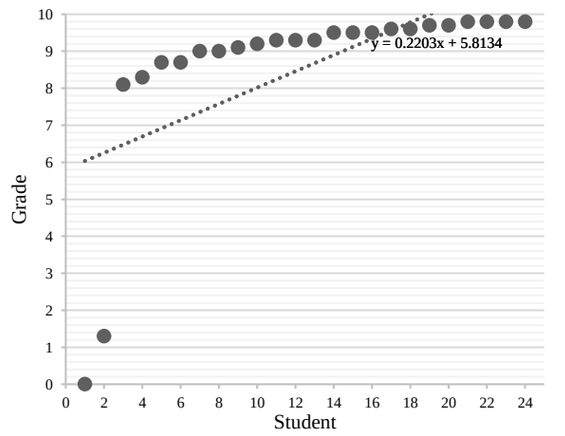
The grades were variable and their frequencies are presented in Graphic 3, through a Histogram, where it can be seen that 4 students had a grade of 10, 3 students 9.3, 2 students 8.7, 2 students 9.0, 2 students 9.5, 2 students 9.6, 2 students 9.7 and the remaining 6 students had grades of 0, 1.3, 8.1, 8.3, 9.1 and 9.2 each.



Graphic 3 Histogram of grades obtained from group 2.

The average academic achievement of GROUP 2 was 8.6, 22 students with a passing grade, representing 92% of the total, and 2 students with a failing grade, representing 8%.

Graphic 4 presents the scatter plot of the 24 grades and the linear regression that represents them in order to analyze the mathematical model of the equation of the line (2).



Graphic 4 Regression dispersion Linear ratings for group 2

The equation of the line (2) has a slope m of 0.2203, which when calculating its arc tangent gives us 0.216836437 radians, which is equivalent to a slope angle of 12.4238127degrees.

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Conclusions

It can be observed that the average school achievement and the percentage of students passing in GROUP 1 was lower than the achievement of GROUP 2.

On the other hand, the histogram of GROUP 2 shows a higher frequency of students with grades between 8.9 and 10 than the histogram of GROUP 1.

The scatter plot of GROUP 1 shows the rare cases of 4 students with a score of 0, which results in the slope of the linear regression line being greater than that of GROUP 2.

The angles of inclination of the straight lines of GROUP 1 and GROUP 2 with values of 19.7329102 degrees and 12.4238127 degrees respectively, denote a greater inclination in the straight line of GROUP 1, consequently, there is a greater variation between the grades of the students with respect to GROUP 2.

It is notorious that the use of this online GDB tool made easier the communication between the students and the teacher in the development of the practices with the C++ language and that therefore it had a positive influence in the scholastic achievement of the Programming Learning Unit of the Bachelor's Degree in Energy Engineering.

Therefore, it is concluded that the use of GDB Online as a Virtual Laboratory represents a viable and reliable learning strategy to improve academic achievement.

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