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Journal Computer Technology

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Presentation of content

In volume five, issue fifteen, as the first article we present, *Effectiveness of the use of a learning object in students of the programming area in higher education*, by CASTILLO-PÉREZ, Iliana, ALONSO-LAVERNIA, María de los Ángeles, MUÑOZ-SÁNCHEZ, Yira and MARTÍNEZ-LAZCANO, Verónica, with secondment at the Universidad Autónoma del Estado de Hidalgo, as a second article we present, *Virtual laboratory as a strategy in distance education for programming in the face of COVID-19*, by MEX-ALVAREZ, Diana Concepción, HERNÁNDEZ-CRUZ, Luz María, CASTILLO-TELLEZ, Margarita and FLORES-GUERRERO, Mayra Deyanira, with an appointment at Universidad Autónoma de Campeche and Universidad Autónoma de Nuevo León, as a third article we present, *COVID-19, ICT and taught. A challenge for engineering professors*, by SOTO-HERNÁNDEZ, Ana María, CAMERO-BERRONES, Rosa Gabriela and VARGAS-PÉREZ, Laura Silvia, with secondment at Instituto Tecnológico de Ciudad Madero, as fourth article we present, *Industry 4.0: The new educational paradigm?* by MARTÍNEZ, Bahena Elizabeth & ESCAMILLA, Regis Daisy, with secondment Tecnológico de Estudios Superiores de Cuautitlán Izcalli.

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Article
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Effectiveness of the use of a learning object in students of the programming area in higher education

Eficacia del uso de un objeto de aprendizaje en estudiantes del área de programación en el nivel de educación superior

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Abstract

This paper shows the application of a Learning Object (LO), to teach an Object Oriented Programming theme, considering the involvement of the levels of the thinking skills according to Bloom´s taxonomy and the strategies for the development of activities that support autonomous learning. The kind of research used to measure the effectiveness of the applied multimedia material is exploratory-investigative. The selected sample was 110 students who attended the subject, 23 of them constituted the experimental group and the other 87 the control groups. In order to appraise the students learning, a cognitive assessment instrument was designed, in addition to a questionnaire to evaluate the quality of the educational material from the user´s perspective. The results when comparing the scores obtained by the experimental group with the established control groups show a favorable increase in the students' approval rate for the topic, perceiving a favorable autonomous learning.

Learning object, Programming languages, Higher education

Resumen

El presente trabajo muestra la aplicación de un Objeto de Aprendizaje (OA), para la enseñanza de una temática de Programación Orientada a Objetos, considerando el involucramiento de los niveles de habilidades del pensamiento de acuerdo con la taxonomía de Bloom y de las estrategias para el desarrollo de actividades que apoyan el aprendizaje autónomo. El tipo de investigación utilizada para medir la eficacia del material multimedia aplicado fue exploratorio-investigativo. La muestra seleccionada fue de 110 estudiantes que cursaron la asignatura, de los cuales 23 constituyen el grupo experimental y 87 pertenecientes a los grupos de control. Para valorar el aprendizaje de los estudiantes, se diseñó un instrumento de evaluación cognoscitiva, además de un cuestionario para evaluar la calidad del material educativo desde la perspectiva del usuario. Los resultados al comparar las calificaciones obtenidas por el grupo experimental con los grupos de control establecidos muestran un incremento favorable en el índice de aprobación de estudiantes para el tema abordado, percibiendo un aprendizaje autónomo favorable.

Objeto de aprendizaje, Lenguajes de programación, Educación superior

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Introduction

The trend in the use of Information and Communication Technologies (ICT) within education has increased so much that they are currently used on a day-to-day basis as part of the teaching-learning process.

A wide variety of methods, methodologies, strategies, approaches or techniques have been implemented with the intention of supporting student learning and improving their academic performance, in recent years those that strengthen student autonomy have highlighted, such as the inverted class, Orozco-Infante (2020), mentions that not only is the transfer of time and space in the learning process beneficial, but of the timing and proper use of digital resources; another strategy that has attracted attention has been gamification, which seeks through the use of game mechanics, to guarantee the competency and active learning of the student, discovering that the innovative use of ICT benefits their learning and motivates them (Lazarte & Gómez, 2021). For their part Valenzuela, Ramírez, Arellano, and Mondaca (2021) highlight the importance of feedback in formative evaluation processes in virtual teaching-learning environments (EVEA), in which technology has been shown to improve efficiency and effectiveness in student performance.

Learners from all areas of knowledge benefit from the use of digital teaching materials because they allow them to present more effectively the knowledge they require for their development as professionals, which is due to the management, already natural, of multimedia that make the interaction with these resources more attractive and motivating. Another benefit of the use of didactic resources is that students can carry their own pace of learning, allowing that by interacting independently with digital didactic materials, students identify their own learning strategies to appropriate the knowledge immersed in these technological environments, which strengthens them in their training and prepares them to perform in the future in the professional field.

Digital teaching materials have characteristics that enrich the training process as well as motivate learning and facilitate didactic and formative action.

The latter two, because they act as a guide with a defined didactic strategy and provoke the appropriation of knowledge respectively.

Under this conception, in education, ICT has been used for the benefit of students, allowing them to be at all times close to information, living in the age of knowledge in a way in which they can access at any time and from anywhere to educational content that allows them to promote their autonomous learning, and even socialize knowledge in a much more agile way.

In this sense, autonomous learning allows the student to be the protagonist of their own development, giving them the responsibility of planning, organizing and carrying out the pertinent actions and at their own pace to obtain the objective learning, which in turn will allow them to strengthen the competence of autonomy, which is of vital importance for their inclusion in today's society (Lobato, 2006; Torrano, Fuentes, & Soria, 2017).

Many are the studies that disseminate the relevance of technology as a means for training, demonstrating the effectiveness of its use, and in this sense the Learning Objects (LO), are characterized by their reusability, which implies a certain degree of granularity, focused on a particular objective of learning, with availability so that the student learns at any time and place at his own pace, through interactive multimedia activities, allowing him, in the end, to know his learning through elements of self-assessment included, facilitating autonomous learning (Almendra & Elvas, 2020; Cabrera, Sánchez & Rojas, 2016; Redmond et al., 2018; Williams, O'Connor, Windle & Wharrad, 2015); emulators stand out for their ability to manipulate variables in a virtual environment, represent real or hypothesized phenomena, provide a dynamic and interactive learning experience for students on a particular topic (Falloon, 2019; Jamil e Isiaq, 2019).

Multimedia applications, enriched with videos, texts, audios, graphics, animations, among others, promote the development of digitales skills related to the use of ICT (knowing how to access, search and select information according to the student's own learning objective), motivate the student according to their dynamics and challenges proposed for the acquisition of knowledge (García & Tejedor, 2017; Huertas & Pantoja, 2016; Nketiah-Amponsah, Kumi Asamoah, Allassani & Kwami Aziale, 2017; Sánchez & Espada, 2018; Yáñez & Nevarez, 2018); echomendators and intelligent systems are used to guide learning activities and the selection of resources in the learning path of each student, in deposition of their pace, abilities and motivations, which influences the autonomy of their learning (Rodríguez Chávez, 2021; Romero, Saucedo, Caliusco & Gutiérrez, 2019), all the technological tools mentioned have been applied at different educational levels and various areas of knowledge with favorable results, manifesting the improvement of school performance and student motivation.

With all the above, it is demonstrated that the use of didactic resources, accompanied by methods, strategies, methodologies or approaches, impacts on all areas of knowledge because they lead to a learning process that depends on the learner's own effort (autonomous learning) and their motivation. Hence, technological tools in the form of digital teaching materials represent a relevant support in the training trajectory of every student, making prevailing the need for mastery of digital skills by teachers for their development (García Vélez, Ortiz Cárdenas, & Chávez Loor, 2021).

In this context, and referring to educational programs focused on computing and specifically, in subjects such as Object-Oriented Programming (OOP), students become more competent the more independent and hard-working they are, and this is because they look for a way to solve for themselves the problems they face in the development of their tasks, on the contrary, its kinesthetic profile makes theoretical topics more complex to learn.

Despite the kinesthetic characteristics of this area, learners require the acquisition of theoretical knowledge, which is fundamental for the mastery of knowledge, with the intention that they understand and appropriate it, which is essential to later apply it (Muradul & Latiful, 2016; Ochoa, 2018; Öqvist & Nouri, 2018). The same is indicated by Figueredo and García-Peñalvo (2018) "Programming is a process of transformation of a mental plan of ordinary terms into terms compatible with the computer" (p.2), which is not easy for students, since it requires the development of abstract thinking skills to be able to create computer programs that solve real problems (Sánchez-García, Urías-Ruiz, & Gutiérrez-Herrera, 2015; Insuasti, 2016).

The topic of constructors for any object-oriented programming subject is basic, as it represents the genesis of objects, since they are created from the constructors and are initialized with valid values that subsequently change their state during the course of the application, so it will be of great importance that students learn various concepts and rules that they must then implement correctly.

Consequently, for these theoretical topics, the use of didactic resources becomes even more motivating, since they provide a different alternative to books or textual sources that could be rejected by students who are more attached to technology, this with the purpose that they can, firstly, appropriate all relevant information for their learning and secondly, strengthen autonomous learning skills.

Some study evidence, focused on learning programming, has had the objective of investigating the impact of ICT on the learning of concepts and the development of programming skills and has come to the conclusion that digital educational materials must include certain aspects for this task to be fulfilled, Jamil and Isiaq (2019) highlight the importance of educational material linking learning content with future work and the profession, and that it should include behavioral, emotional and cognitive exercises in a balanced manner; Lappalainen, Lakanen and Högmander (2016) mention the need to include exercises and tests to improve learning efficiency, while Muradul and Latiful (2016) point out that including a problem bank supports learning.

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The above criteria promoted the development of a Learning Object (LO) on the types of constructors in the C++ programming language, which reinforces the self-learning of said topic as part of the theoretical concepts of the students of the subject of OOP.

This type of resource was selected, since in recent years its use has reached great relevance because it is a digital didactic unit designed to achieve a learning objective and to be reused in different learning environments and in different contexts, in addition to having metadata that favors its location, and allows to address its contextualization (Astudillo, 2011; Dabbagh et al., 2016; Frantiska, 2016).

The LO are instructional components focused on detailing a concept, procedure or specific knowledge with an essential characteristic that is the ability to be self-contained, that is, where external references are not required to achieve the proposed learning objective, being all explained within it and preferably, but not mandatory, includes exercises and/or evaluations to feed back to the student.

As has been observed, in the international context, there has been much evidence of the success achieved through LO, and the educational methodological change caused by the current pandemic has contributed to the increase in the production of digital educational resources that support the continuation of studies by the students. In Mexico 7.1 million higher-level students are enrolled in the 2021 school year, and 65.3% have a laptop or desktop computer, while 34.7% continue their studies through smartphones or tablets (INEGI, 2021), therefore, another important reason for working with LO has been their characteristic of being adaptable (responsive) to the electronic device in which they are used, in addition to not requiring that they be necessarily accessed through a repository, which facilitates their access by students.

This paper presents the application of LO on the topic of Builders in C++ for incorporation into the subject of OOP in order to promote autonomous learning of students of the Bachelor's Degree in Computational Sciences or related careers. It is important to note that, responding to the quality guidelines, its development was based on the Methodology for the Development of Learning Objects (MEDOA) (Alonso, Castillo, Martínez, & Muñoz, 2013a) and its effectiveness as educational material was validated, as well as its quality from the user's perspective through the results obtained by the students who used it.

In order to facilitate the understanding of the study carried out and the characteristics of this LO, the work has been structured in the following sections: *Development of the LO* where the primary elements of the educational material in relation to learning are described and highlighted; *Methodology,* section that presents the objective and way of carrying out the study; in section 3, the *Results* obtained both in the implementation of the LO and its assessment by the users; in section 4 a *Discussion* of said results and possible improvements is included and finally, the *Conclusions*.

Learning Object Development

Considering that a methodology is a set of guided, systematized and structured steps to carry out research in an appropriate way, the development of an LO requires a methodological process in an indispensable way for its creation, in the same way that any technological system needs it.

A methodology must guarantee compliance with the essential requirements in the creation of the didactic material, as well as the development process itself, in addition to enabling the control and monitoring of this process. Under these reasons, and even though there is a diversity of methodologies for the development of LO, the use of MEDOA was chosen because it is a methodology that guarantees the fulfillment of these purposes and above all, because it supports the entire creation process.

MEDOA, consists of seven phases: planning, analysis, design, implementation, validation, implementation and maintenance for the process of creating an LO, considering not only its development, but also the implementation to make it available to users and maintenance for its modification or expansion.

Within the phases of this methodology, the following aspects of the LO were established: the digital material is aimed at students of upper middle or higher level and in the user´s profile the knowledge, skills and attitudes are considered so that he can learn with the LO, such as: basic knowledge about programming, basic use of the computer, proactive and collaborative attitude. In addition, the Builders in C++ LO includes five examples, each of which presents the implementation of a constructor type. In the case of the activities, three are presented with different level in the skills of thinking in correspondence with Bloom's taxonomy, the first verifies the learning of theoretical concepts through the creation of a conceptual map on the constructors that involves actions of analysis and synthesis of thought (knowledge), the second activity considers the application level by referring to the coding of an object class that implements some of the concepts learned within a preset structure, the third achieves a minimum level of synthesis by requesting the coding of at least two different types of constructors within a new class of objects (constructor overload), as well as an application in which the objects that invoke them are urged; the last two activities are intended to develop in the student the know-how, in addition to suggesting that they be carried out under a collaborative learning strategy, promoting the socialization of learning.

On the other hand, in the evaluation section, three are contemplated that make use of different types of reagents such as false/true questions, multiple choice, complete, relate columns, multiple selection, among others. Notably, the questions also consider levels of thinking skills ranging from knowledge to analysis in relation to Bloom's taxonomy.

On the other hand, the defined activities have an identifier, the learning objective (according to Bloom's taxonomy), the instructions, the type of evidence to be delivered, the time required for the activity, the type of evaluation (Heteroevaluation, Co-evaluation or Self-Evaluation), as well as the qualification or score that can be obtained.

It is important to mention that MEDOA contemplates a series of guidelines that define a base structure with the intention of standardizing the development of LO and ensuring that they have characteristics that distinguish them from other types of educational software (Alonso Lavernia, Castillo Pérez, Pozas Cárdenas, Martínez Lazcano, & Muñoz Sánchez, 2013b). The resource developed under this methodology is composed of various elements, which are:

- Introductory.
- Content.
- Reinforcement-Evaluation.
- Complementary.
- Identification and Location.

The intrinsic knowledge of the topic addressed in the LO is broken down through the elements of the didactic resource, being able to use sections and subsections for its presentation through interactive materials with which the student will learn the theoretical concepts, reinforcing their application with examples.

The elements of reinforcement and evaluation are introduced as a fundamental part within a digital didactic material since with these the probability of assimilating the knowledge that is learned with the didactic resource is increased. For the Constructors in C++ LO, they are applied through the different activities and evaluations that allow to strengthen the knowledge and skills that are described in the content elements. This material includes, as indicated by the MEDOA methodology, three activities.

All evaluations provide feedback for each of the items they present. On the other hand, the complementary elements support all the above, by providing help to the user for the understanding of the content. These elements are materialized with the sections: *glossary* (the meaning of certain terms used in the LO is presented), *bibliographic references* (as a way to expand the knowledge presented) and *credits* (the authors of the LO are recognized).

The combination of all these elements allows users to have various learning strategies based on the use of multimedia, evaluation and exercise techniques. In addition, some of them support the user to develop autonomy and independence capabilities in their learning.

Methodology

To validate the effectiveness of the didactic resource developed in the learning of the students, a methodological design was followed that consisted of the following steps:

1. Definition of the objective of the research

2. Definition of the type of research

3. Definition of variables

4. Selection of the sample and application of the didactic resource

5. Obtaining results and discussion

The steps of the methodological strategy of the research carried out are described below.

Definition of the research objective

The purpose of this study is to know the effectiveness of the use of learning objects as educational materials that promote the autonomous learning of students in the area of programming, by addressing topics with extensive theoretical bases.

Definition of the type of research

According to the defined objective, the research to be carried out can be framed in two research approaches:

1. *Exploratory,* as it is a known scientific problem, since it has been worked by various authors to demonstrate the effectiveness of the use of digital didactic materials, reaching a certain level of clarity, however, work continues to establish causal relationships between technological resources and learning.

2. *Development work and technology evaluation,* because it is a study dedicated to completing, developing and perfecting new materials, products or procedures. In this case, the work is a research study based on the same methodological patterns as any other research, the purpose being to know the validity and reliability of the technique or technology or to quantify the benefits it produces and the impact that its introduction has had in practice.

Definition of variables

To evaluate the effectiveness of the Learning Object from the point of view of the pedagogical contents, depending on the conception of learning and the application of knowledge by students, the following considerations are established for the analysis:

a) It is considered a history of the results obtained in the partial evaluation, by the students who have regularly taken the subject of OOP and who had not used interactive educational materials as a means of reinforcing learning and promoting autonomy in the student. For this analysis, only those items within the partial theoretical-practical evaluation of the normal course, which correspond to the topic of constructors in C++, are considered.

b) An *ad-hoc* test was designed to measure the learning achieved after having interacted with the LO and having developed the activities and evaluations proposed in it. The test was composed of six items, of which four were considered to estimate the theoretical concepts and two, particularly, for the assessment of the implementation of these concepts (items 4 and 5), since it is requested that through the evaluation of a code, the relationship that has the instantiation of a series of objects with the type of constructor that is presented in the code of the class of objects and for which, the student must go through several levels of thought in Bloom's taxonomy (Knowledge of the theoretical concept, up to evaluation, to deduce or assess its implementation), considering that only the one who has reached the highest levels will be able to respond correctly to these items, thus demonstrating the achievement of learning.

Table 1 presents the relationship of each of the items of the *ad-hoc* test with the level of knowledge within Bloom's taxonomy and the verb to which it refers in relation to the abstract thinking that is demanded of the student to respond adequately.

Ítem	Level of knowledge in Bloom's Taxonomy – Verb
1	Remember – Define
2	Understand – Predict
3	Analyze – Differentiate
4	Evaluate – Relate
5	Evaluate – Evaluate
6	Evaluate – Evaluate

Table 1 Level of knowledge requested in the items of the *ad-hoc* test
Source: (self made)

Selection of the sample and application of the didactic resource

The study was carried out at the Autonomous University of Hidalgo State, using the Builders in C++ LO in an experimental group of 23 third-semester students who took the subject of Object-Oriented Programming from a total sample of 110 enrolled in the six periods evaluated, all of them from the educational program of Bachelor´s Computer Science.

As already mentioned, the analysis of the results was carried out among the history of the evaluations presented by the control groups, whose students have previously taken the subject and have not used the Learning Object, compared to the experimental group that applied the *ad-hoc* evaluation, after having used the LO. To assess the quality of the LO, an instrument was applied to the same 23 students who worked with it, because according to some authors it is important to evaluate a didactic resource from the perspective of the user (Alonso et al., 2019; Gordillo, Barra & Quemada, 2018; Massa, De Giusti & Pesado, 2012; Velázquez et al., 2014).

According to Morales, García, Moreira, Rego and Berlanga (2006), a comprehensive evaluation of the quality of a digital educational material must consider many aspects and be evaluated from various approaches. For this study, the criteria of Morales et al. (2006) regarding the following aspects were taken into account: *psychopedagogical* to evaluate the adequacy of the contents to the users, the depth and relevance; *didactic-curricular* to determine the level of relationship between the LO and the curricular objective according to the context in which it was applied; *technical-aesthetic* oriented to assess its degree of legibility, adequate colors, size of letters, design, all with the intention of motivating the user; and finally, *functional* to assess if it is an effective and usable LO and does not hinder the navigation and learning of students..

According to the authors, psychopedagogical and didactic-curricular criteria are of greater importance within an educational context since a didactic resource could be very functional, but not be adequate to the characteristics of the users or not meet the learning objective.

In addition, some aspects to be evaluated for each criterion were established, which are shown in Table 2. The Likert Scale was used in the range: strongly disagree, disagree, agree and strongly agree for its assessment.

Criterion	Aspects
Psychopedagogical	The learning objective is clear. The learning object helped him to better understand the subject. The examples are clear for each of the cases. The activities are understandable. The examples have to do with the computer science profession.
Didactic-curricular	The content of the object is adequate for the achievement of the learning objective. The learning object provides feedback. The examples were according to the theme. The activities allow you to develop other skills in addition to programming.
Technical-aesthetic	The font used is the right one. The font size is adequate. The color used in the learning object is appropriate.
Functionality/ Navigation	The navigation is understandable. Navigation buttons are visible. No broken garters were found.

Table 2 Aspects to assess the quality of the LO from the perspective of the students
Source: taken and modified by Morales et al. (2006)

Results

The results achieved are presented in two parts, one dedicated to the application of the Learning Object and the other, related to the application of the evaluation instrument of the resource mentioned.

Application of the Learning Object

The scores obtained by the students of the experimental group in each of the items that make up the *ad-hoc* test are presented in Table 3.

No. Pupil	Ítem 1 (1 pto)	Ítem 2 (1 pto)	Ítem 3 (1 pto)	Ítem 4 (2 ptos)	Ítem 5 (5 ptos)	Ítem 6 (2 ptos)
1	1	0	1	2	3	2
2	1	0	1	0	1	2
3	1	0	1	2	4	2
4	0	0	1	2	5	2
5	1	1	1	2	3	1
6	1	0	1	0	2	2
7	1	0	1	2	4	2
8	1	1	1	2	4	2
9	1	1	1	2	4	2
10	1	1	1	0	5	2
11	1	0	0	0	2	1
12	1	0	0	0	2	1
13	1	0	1	2	4	2
14	1	0	1	0	4	1
15	1	0	1	0	2	2
16	1	0	1	2	4	1
17	1	0	0	2	5	2
18	1	0	0	0	4	1
19	1	0	1	2	3	2
20	1	0	1	2	4	2
21	1	0	0	0	4	2
22	1	0	1	2	3	2
23	1	0	1	2	4	2

Table 3 Results of the experimental group in each item of the knowledge test
Source: (self made)

In general, it can be observed that except in item 2, in the rest of the items most of the students obtained the highest score, which indicates that the use of the didactic resource to complete the learning of the students in this subject was satisfactory.

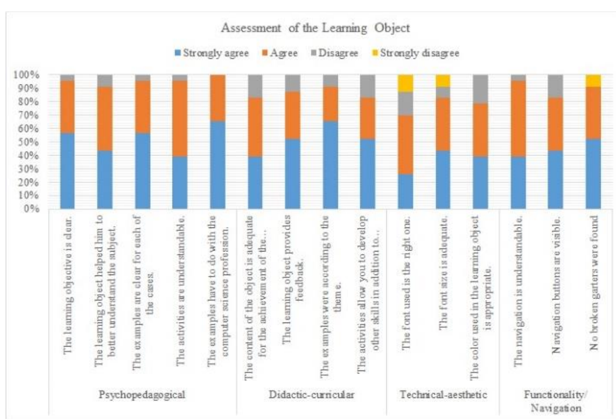
On the other hand, the results obtained by the students of the experimental and control groups in the partial theoretical-practical evaluation of the subject of OOP, for the school periods analyzed, are presented in Table 4.

Group type	Period	Approved	Failed	Total students
Control groups	Cycle1-A	53.33%	46.67%	15
	Cycle1-B	28.00%	72.00%	25
	Cycle2-A	46.15%	53.85%	13
	Cycle2-B	65.00%	35.00%	20
	Cycle3-A	35.71%	64.29%	14
Experimental group	Cycle3-B	73.91%	26.09%	23

Table 4 Index of results obtained by students from different groups
Source: (self made)

Implementation of the LO Assessment Tool

The results achieved in the application of the evaluation instrument are presented in Graph 1, with 47% of students valuing the set of aspects with *Totally agree*, 41% *Agree*, 10% evaluated it *In Disagreement* and 2% as *Totally disagree*. It should be noted that the main aspects that were negatively valued by the students are the technical-aesthetic and functionality-navigation criteria.



Graphic 1 Results of evaluation of the LO by the user
Source: (self made)

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Among the aspects best valued by users are *the examples have to do with the profession of computational sciences* of the psychopedagogical criterion and *the examples were in accordance with the theme* of the didactic-curricular criterion; in general, the criterion best valued by the users was the psychopedagogical one, where *the objective aspects of learning* and *clear examples* also obtained favorable scores; the aspects of *the LO provide feedback* and *the activities allow the development of other skills in addition to programming* favored the general score of the didactic-curricular criterion, however, the technical-aesthetic criterion presented the most unfavorable scores, so the aspects related to *the type and font size* and *the color used in the LO* should be improved in the maintenance step, as well as *the links for navigation*, the Functionality/Navigation criterion, which also had some unfavorable points, should be verified.

Discussion

When analyzing the results of the knowledge test of the experimental group (Table 3), it was observed that in items 1, 3 and 6 scores were obtained that adequately satisfy the achievement of learning; in item 4 and item 5 (considering for the latter that 4 and 5 points reflect a good level of achievement) it was achieved that 60.87% of the students responded correctly. Regarding item 2, only four students were able to answer with certainty, which could mean that the item was not formulated correctly or the way in which the topic was addressed in the LO was not enough or it was necessary to reinforce it through the activities and/or evaluations.

When examining the set of results, it is clear that the use of the Learning Object achieved an increase in the percentage of students approved (73.91%), since in the control groups, the best approval rate had been 65%.

As for the evaluation of the quality of the LO by the students, it can be interpreted that it is quite satisfactory (88% favorable) and the disagreements are mainly focused on the aspects of aesthetics and functionality, whose improvement is achieved by attending to some programmatic issues of this resource.

Conclusions

The results of this study corroborate that the use of digital didactic resources harmonizes perfectly with the methods of learning theoretical contents in computer science, in particular, programming languages, demonstrating that they are efficient to improve the performance of students and promote their autonomous learning.

It should be noted that to achieve favorable results it is essential to carry out a process of elaboration of the resource that from the first moment attends to its quality. In the particular case of the study presented, the use of the MEDOA methodology for the creation of the LO has been key to achieving the effectiveness of this resource, since in each step of its development the articulation of the different elements that compose it is considered responding to the learning needs of the topic that is addressed, as well as the relevance of activities and assessments that reinforce knowledge, all based on the established learning objective and the levels of thinking skills to be promoted.

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Article

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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)

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)

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.

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.

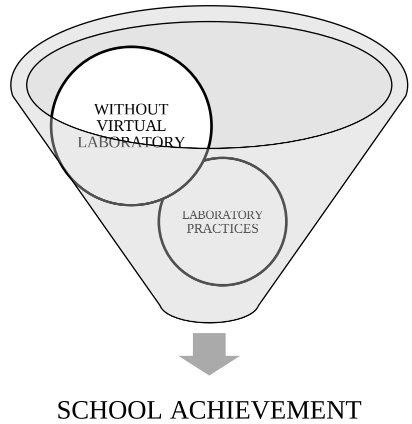


Figure 2 Conditions Group 1. School achievement without virtual laboratory
Source: Prepared by the authors

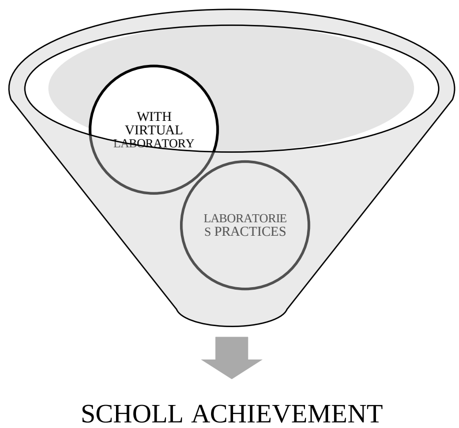


Figure 3 Conditions Group 2. School achievement with virtual laboratory
Source: Prepared by the authors

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.

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.

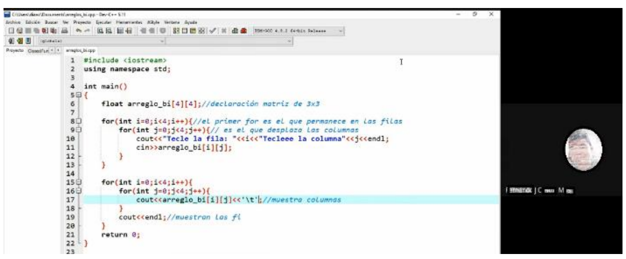


Figure 4 Student sharing his screen in the Meet application, to verify his code using DEVC++
Source: Prepared by the author

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.

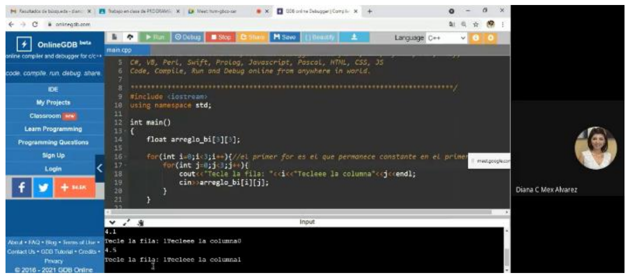


Figure 5 Use of GDB Online in the Synchronous Programming Classroom
Source: Prepared by the authors

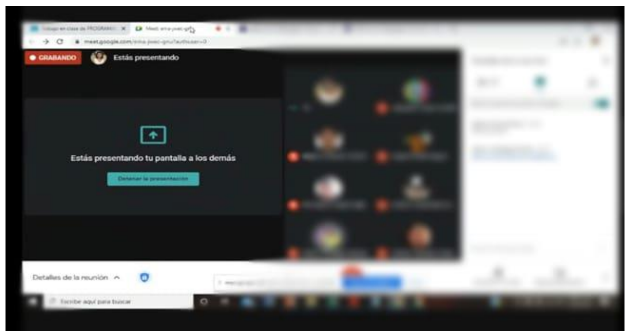
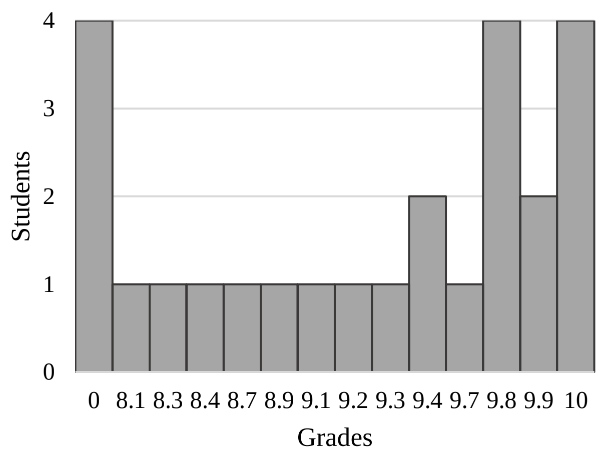


Figure 6 Monitored students' practices synchronously with GDB Online as a Virtual Lab
Source: Prepared by the authors

Results

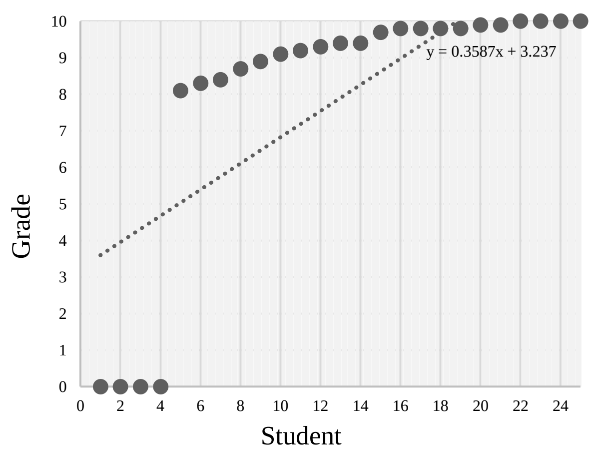
In the school cycle 2019-2020 F2, a total of 25 students were enrolled in the Programming Learning Unit, who used the DEV C++ as compiler of the 5 practices corresponding to the second partial and the Meet application as a means of synchronous communication. The grades were variable and their frequencies 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.



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).

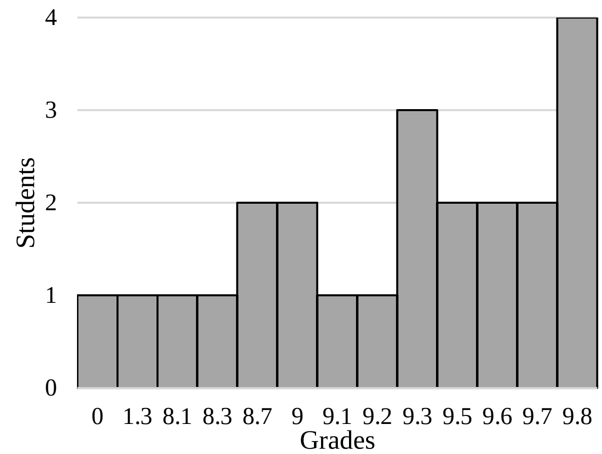


Graphic 2 Regression dispersion Linear ratings for group 1

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.

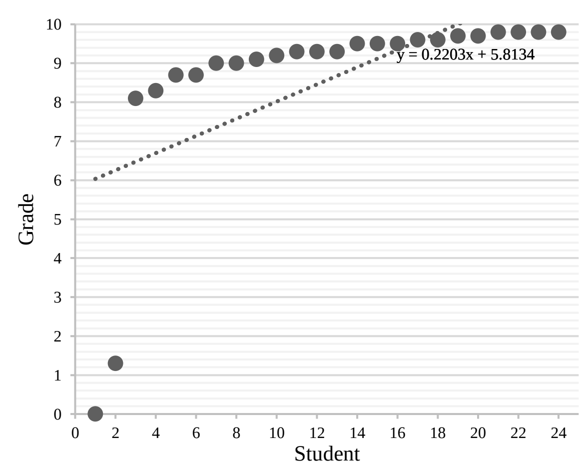
The grades were variable and their frequencies are presented in Graphic 3, through a Histogram, where it can be seen that 4 students had a grade of 10, 3 students 9.3, 2 students 8.7, 2 students 9.0, 2 students 9.5, 2 students 9.6, 2 students 9.7 and the remaining 6 students had grades of 0, 1.3, 8.1,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

Thanks

The authors thank the Faculty of Engineering of the Autonomous University of Campeche for the facilities granted to carry out and disseminate this work.

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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Article

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COVID-19, ICT and taught. A challenge for engineering professors

COVID-19, TIC y enseñanza. Un desafío para profesores de ingeniería

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Abstract

A study is presented with professors and engineering students at a technological institute in Mexico, on the working conditions derived from social confinement by COVID-19. As well as the benefits that students have observed derived from this virtual or distance study modality. Some findings show that 94% of teachers immediately found a technological alternative, motivated by intensive training (71%) and self-learning (64%). The most used resources: written files (87%), video calls (84%), and chat (78%). The students agreed on its importance, but they appreciated the inclusion of recreational resources. Student problems: access to a sufficient and stable internet service, and stress due to various causes. Half of the teachers also had problems with the internet and the students' absences from virtual classes.

COVID-19, Professors, Engineering students, ICT

Resumen

Se presenta un estudio con profesores y estudiantes de ingeniería en un instituto tecnológico de México, sobre las condiciones de trabajo derivadas del confinamiento social por el COVID-19. Así también sobre los beneficios observados por los estudiantes derivado de esta modalidad de estudio virtual o a distancia. Algunos hallazgos muestran que 94% de los profesores encontraron de forma inmediata una alternativa tecnológica, motivada por la capacitación intensiva (71%) y el autodidactismo (64%). Los recursos más utilizados: archivos escritos (87%), videollamadas (84%), y chat de (78%). Los estudiantes coincidieron en su importancia, pero agradecieron la inclusión de recursos lúdicos. Problemáticas de los estudiantes: acceso a un servicio de internet suficiente y estable, y estrés por diversas causas. La mitad de los profesores también tuvieron problemas con el internet y las ausencias de los estudiantes a clases virtuales.

COVID-19, Profesores, Estudiantes de ingeniería, TIC

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Introduction

The COVID-19 pandemic forced education authorities around the world to declare social confinement. In Mexico, activities in schools were suspended from the second half of March 2020 and instructions were issued to design a strategy to reopen activities, a situation that included all educational levels.

Many professors responsible for engineering courses, especially older ones, before the COVID-19 pandemic, had their didactic strategies based on the blackboard and chalk, notes and questionnaires, paper exercises and laboratory practices with experimental equipment. The use of technology in some cases was unthinkable, not even optional.

The attempt to motivate these teachers to study, analyze, evaluate, and apply another variety of didactic resources and platforms for learning management, related to new technologies, although repeated, had not been successful. Teachers considered the use of mobile devices (MD) in the classroom as a distraction in learning.

However, some teachers did work with strategies that included them, at least for communication, through the most common social networks such as Facebook and WhatsApp. These networks have been studied and classified as potentially positive in learning (Hershkovizt and Forkosh-Barush, 2017; Gómez-del-Castillo, 2017; Ahern, Feller and Nagle, 2016; Amry, 2014; Gavilan, Martínez-Navarro, and Fernández-Flores, 2017).

Likewise, other higher education professors were already working in some institutions, with educational platforms that made it possible to institutionalize learning management and unify efforts for the benefit of communities. Before COVID-19, the best known, due to its free access, was Moodle, although Schoology and Claroline also have their free versions, not to mention those that require licenses such as Blackboard.

Because it is the most widespread, Moodle has been studied more consistently (Rodríguez Correa and Rivadulla López, 2015), but it requires constant training of teachers to maintain contact and motivation of students (Hobbs and Tuzel, 2017; Dahlstrom, 2015) since they involve the development of specialized teaching resources for the virtual or distance modality.

At the beginning of the COVID-19 pandemic, the activities within each of the higher education institutions (HEI), public and private, were reorganized according to their internal situation and that of the environment. As in all areas, the uncertainty of the immediate future was wide, and managers tried to achieve minimal compliance with educational programs. The instructions to adjust the teaching-learning conditions and the school calendar were particularized in higher education institutions in Mexico (Malo Álvarez et al., 2020). The semester ended under emergency conditions.

By the second semester of 2020, the HEI had already deployed an intensive teacher training program, preventing a non-return to face-to-face classes. With this, institutional technological resources were chosen to guarantee a certain uniformity in the educational process, some in free access format and others through the acquisition of a license, but all had a means of communication with the students.

However, the need for a resource with video calls for synchronous communication motivated the use of Zoom platform, Google's Meet, Microsoft's Teams, although others continued their work base in those already mentioned, and even in WhatsApp and Facebook.

Professors, and students of the HEI made a series of decisions regarding their technological equipment, the desktop or laptop computer, the tablet or the smart cell phone that had to support the management of the platform established for this purpose. Some teachers decided to invest in cameras and accessories to record their classes, or the acquisition of a smart board to replace their white board in the classroom.

Also, another need was the connectivity of their device, with a service that would allow them to follow the courses, from the most appropriate place possible, in terms of environmental conditions. Which has been one of the most difficult circumstances for students and teachers of HEI in Mexico, since in almost all families there are several members making use of the internet, in small spaces, which complicates participation with an open camera and microphone.

However, according to Soni (2020), the priority during 2020 was to share: written materials in different editable and non-editable formats, thematic images, and videos available on different platforms, internet pages with adequate content, free simulators for different purposes.

At the same time, a change was necessary in the administrative procedures of the HEI, to address the situations of students and teachers, which affected the regularity of a school year. Significant flexibility in school procedures was warranted.

All this unprecedented process forced by COVID-19, has not been trivial for students according to Di Pietro et al. (2020), since it causes great inequalities in cognitive abilities affecting their motivation and emotional well-being. Psychological problems derived from isolation that affect behavior and their cognitive and non-cognitive abilities have short- and long-term consequences that should be studied.

In this sense, the National Technological Institute of Mexico promoted a virtual space on its website for students and teachers of the different campus to give testimony of their initiatives and efforts to continue the educational process during the COVID-19 pandemic (TecNM, 2020).

A year later, in March 2021 the impact continued, with more than four million higher education students in confinement. Meanwhile, various strategies had been generated at the global level to address this situation. COVID-19 had affected everyone, rich and poor countries alike, but the response was mixed.

These situations common to higher education teachers in the world, excluding those dedicated to the virtual or distance modality, have been recovered from supranational perspectives such as the different guides, recommendations, surveys and reports of: the World Bank (World Bank, 2020. 2021), the International Institute for Higher Education in Latin America and the Caribbean of the United Nations Educational, Scientific and Cultural Organization (IESALC, 2020), the International Association of Universities (Marinoni G., 2020), the Carolina Foundation (Pedró, 2020), the European Union (Di Pietro et al., 2020), the Organization for Economic Cooperation and Development (OECD, 2021), and the Organization of Ibero-American States (Sáinz et al., 2021).

But also, under this need generated by COVID-19, the educational process in HEI has been investigated and reported from different angles and perspectives, some personal, others institutional, inter-institutional, national, and regional. In this sense, Pedró (2020) insisted on the documentation of the “pedagogical changes introduced during the crisis and their impacts; in particular, we must pay attention to the negative effects of emergency distance education, the *Coronateaching* syndrome” (p. 13).

The above, because it had already been shown that the quality of the results in education does not have to do with the presence or absence of technology in schools but with the pedagogy adopted and the conditions in which it is applied in the classroom (Pedró, 2016).

Therefore, a comprehensive diagnosis of the situation should include a review of the professional skills of teachers, but also the infrastructure available in HEI to use technological tools, whether they are computer equipment and mobile devices, programs or applications, and connectivity.

Thus, the main actors of the educational process, students, and teachers, must be characterized, but also their context and antecedents related to the use of Information and Communication Technologies (ICT), Learning and Knowledge Technologies (LKT), and mobile devices (MD) specifically. All within the framework of a defined, conscious, and active pedagogical and didactic strategy.

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By the way, a deficiency that has been identified in higher education in various countries (Paredes-Chacín et al., 2020; OECD, 2021; Pedró, 2020).

This work presents a diagnosis on the advancement of teacher training in the use of educational technologies, and in the knowledge and use of active pedagogical and didactic strategies for distance or virtual education. Likewise, the perceptions and experiences of students in this compulsory educational modality, both from the technological point of view and the personal-emotional and socio-family.

Development

This work was carried out with engineering students and professors at a public technological institute (ITCM), located in the south of the state of Tamaulipas, northeast of Mexico. ITCM offers 10 engineering programs and 10 postgraduate programs, with 460 professors, and had an enrollment of 7,955 students as of the second semester of 2020.

The comparison of four studies is presented, two carried out in 2017 before COVID-19, and two in 2021, one year after social isolation. In both cases, the student population, and the academic community of the ITCM were concerned.

During 2017, a questionnaire was applied to 356 engineering students to identify the use of MD during their studies. It was a representative sample of ITCM enrollment, stratified by career and gender, which allowed the identification of students' perceptions and habits related to the use of MD in the classroom, the activities of their teachers, and indications of their correlation with the gender and career of the students.

The other study from 2017 was carried out to make a diagnosis with ITCM professors about their digital, informational, and pedagogical competences, and their attitudes towards ICT. Motivational elements of innovation were also sought in the development of new teaching resources (Tapia Cortes, Cardona Torres and Quintero Salazar, 2017; Dahlstrom, 2015).

Four years later, at the end of the first semester of 2021, and after a year of social confinement derived from the COVID-19 pandemic, a questionnaire was applied to students who had two full school semesters under the virtual education modality.

The above to know the response of the students to the question: How was virtual teaching learning in engineering attended under this emergency of the COVID-19 pandemic? But the situation of the teachers was also investigated, how they faced the emergency, what decisions they made and what didactic strategy they adopted to carry out their teaching work.

In the case of the 2021 studies, descriptive and interpretive analyzes were carried out. The tools used were the Microsoft Forms questionnaires and spreadsheets.

Students and MD before COVID-19

At the institutional level, it seemed that the school was left out of this transformation (Pedró, 2016), since the initiatives to use ICT and LKT were deployed in a personal way, and the projects were assumed as challenges for teachers. In particular, the case of engineering programs in Mexico, only 6.7% of teachers used social networks as an educational resource (Castro Romero, 2014).

The previous study with the ITCM students showed that 84% of the students had a smartphone, 72% had a navigation service (Soto Hernández and Vargas Pérez, 2018) and 23% affirmed that three or more teachers from this period school used the MD for their courses.

However, the main use of MD by students was distributed in 93% to keep communicated through social networks and 50.8% for leisure through entertainment channels; while only 23.6% knew and used educational applications, and 16.6% knew virtual platforms for learning management (Soto Hernández and Vargas Pérez, 2018) or Learning Management System (LMS).

On the other hand, the students were asked about the courses where the teachers used the MD. 35% affirmed that the teachers of Mathematics and of the subjects of the race do it. Those who used it the least were Physics and Chemistry teachers (11%), and Social and Administrative Sciences teachers (13%) (Soto Hernández and Vargas Pérez, 2018).

Certain significant statistical differences were also identified between the abilities of men and women to manage MD. The responses showed that the highest deviation values refer to the handling of symbols to represent gestures (emoji), the Cloud as virtual storage space, and device synchronization. These last two are the ones with the lowest average, but there a positive correlation with the male gender was observed. The handling of emojis is positively correlated with the female gender. The other skills in the use of MD -notifications, facilities, camera, and configuration- presented the same distribution between both genders of students, and between students of different engineering programs (Soto Hernández and Vargas Pérez, 2018).

Teachers and ICT before COVID-19

The exploratory diagnostic study, carried out in 2017 with the teachers, was focused on digital, informational, and pedagogical competences, as well as their attitudes towards the use of ICT. It was concluded that teachers in general have a favorable attitude towards ICT in their teaching work (more than 70%), however "it is also possible to affirm that the opinion of teachers is not reflected in their actions, they could be rather intentionalities" (Saldaña García, 2018, p. 207). Samples of willingness to train and update are not discussed.

These indicators showed that ITCM teachers said they were willing and with positive attitudes towards the use of ICT, however, students only reported a maximum of 35% of teachers in some areas as users. Furthermore, just under a quarter of the students in the sample had three or more teachers who used them for their course, for teaching and learning purposes. The efforts of the academies of mathematics teachers, and of the subjects of the races seemed to be advancing, although not to the extent that they said (35% vs 70%). The rest had really lagged technological advances.

However, if this maximum of 35% is compared with the 6.7% of engineering professors in Mexico reported by Castro Romero (2014), it could be said that the situation at the ITCM is not among the lowest in the country.

Another conclusion of the exploratory study by Saldaña García (2018) is that the strategy for “teacher training is not associated with the development of technologies and therefore with their pedagogical application to improve learning” (p. 208).

Use of ICT during COVID-19

Since March 2020, the generalized conditions in Mexico for working remotely with students were carried out in an otherwise irregular and heterogeneous way to conclude the semester that had started.

However, teacher training processes were also generated at the ITCM, so that all had minimal competence. By September 2020, there was already a license to use Microsoft's Teams platform (LMS), as well as a good number of associated applications that would allow ITCM teachers and students to have a robust infrastructure for learning management. However, the acquisition of technological equipment and the internet service were still in charge of the teacher and the student.

ITCM teacher response in 2020

The great challenge for teachers was the adoption of a pedagogical and didactic strategy with which to deal with for a whole semester. With low digital competence in the vast majority of cases, as already mentioned, the difficult thing has been the recognition of the need for a still small change in the variety of resources, but a large one in their teaching routine.

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Faced with the emergency of 2020, the response of teachers was perceived as highly diversified: 1) those who learned to use a tablet with a digital whiteboard, almost emulating a face-to-face session using video calls in the LMS; 2) those who worked at home with a white board and with their cell phone transmitted the development during the video call session, or previously recording it to upload it to their virtual group on the LMS; 3) who referred students to videos on the internet or text files, or learned to use other means to generate content, such as Power Point materials that they recorded with sound and placed them in their virtual groups of the LMS and dedicated some sessions synchronous to answer questions about materials; and finally, 4) those who declared themselves incapable of using ICT and requested the official support of a student to manage the educational materials, such as their own digitized notes, and the virtual groups under their responsibility. Among all of them, some of them generated their own version of Flipped Classroom.

A semester later, all the ITCM teachers had already established a virtual or distance work mode at the beginning of the first school term of 2021, which continued under the instruction of social confinement derived from COVID-19.

However, the intensive and extensive training continued focused on the use of technologies for virtual education, with some specific approaches for a certain strategy or technological resource.

For the students, a certain normality was also reached, they already had the equipment and services that they could acquire, they had already deployed their skills to use the applications that the teachers requested, and they had already organized themselves to attend the tasks.

Some with the bare minimum like a smart cell phone and a basic internet that allowed them to follow video calls. In some cases, with many difficulties when being in suburban or rural areas with very limited internet services, which made it difficult for them to attend two parallel activities (such as the teacher's questions and the use of an application to give an appropriate answer).

In other cases, the economic conditions of the students or their family forced them to work during school hours, for which absences were noted to the detriment of cognitive activity. For others, their own health situation or that of their family members also greatly complicated the learning process and meeting the times established by the teacher for teaching.

To identify the situation of teachers and students, beyond a perception in the immediate environment, the 2021 study presented was carried out.

Methodology

An exploratory, descriptive, and qualitative cross-sectional research was carried out at the end of the first school term of 2021. Two questionnaires were used as instruments in Forms, based on the concerns of the students, obtained from various public and private sources, and the observations made to the work of teachers and campus administrators, during the established period, to achieve a triangulation of data. Internal validity and confirmability (Hernández Sampieri, Fernández-Collado, & Baptista Lucio, 2006) was guaranteed with three researchers who reviewed the categorization and interpretations of the responses.

The external validity was confirmed with the readings and analysis of guidelines, reports, and recommendations in published documents. The questionnaires were designed and validated by seven professors from two different departments, to adjust.

Student survey

The questionnaire for students was integrated with 22 questions to retrieve information about teaching work under the virtual modality; 13 of them were multiple choice, five with a Likert scale, and four open. In addition, questions regarding the students' schoolwork conditions were included.

This questionnaire was distributed mainly through ITCM teachers, at the institutional LMS at the end of the courses. Students must have completed the second semester or up to the seventh semester. They had to use their official account to guarantee their identity, so they were not anonymous responses, but they were voluntary.

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259 answered questionnaires were received in July and August 2021, with an average time of 40 minutes. The distribution was 48% women and 52% men, 95% of whom were 18 to 21 years old. The engineering programs they studied: 37% Industrial, 27% Chemical, 9% Business Management, 7% Mechanical, 6% Computer Systems, 5% Petroleum, 3% Environmental, 3% Electrical, 2 % Geosciences, and 1% Electronic.

Teacher survey

The objective of the questionnaire for teachers is to identify the didactic strategy assumed, the training programs, and the problems encountered during the time under confinement by COVID-19. It was made up of 15 items: 10 multiple-choice, three on a Likert scale, and two open questions.

This questionnaire was distributed through the institutional mail to all the teachers at the institute, at the beginning of the second school term of 2021. They also had to answer it from their institutional account to guarantee their identity, which also implied that it was voluntary and identifiable.

101 responses were received (22% from the ITCM academic community) of which 44% were women and 56% men. The age distribution: 95% are 31 years or older, but the most frequent ranges are 27% from 41 to 50 years, and 26% from 61 to 70 years.

The distribution by academic area of the courses attended by the professors who answered the questionnaire: 31% Basic Sciences, 31% Chemical Engineering, 14% Electrical and Electronic Engineering, 13% Economic-Administrative Sciences, 9% Earth Sciences, 8% Systems and Computing, 5% Metalworking, and 4% Industrial Engineering.

Regarding their profile, 18% of the teachers in the sample have a doctorate degree, and 56% have a master's degree. Seniority as a professor at the ITCM is distributed as follows: 37% with 31 or more years of service, 14% with 21 to 30 years, 29% with 10 to 20 years, 17% with less than 10 years, and 13% of professors with a temporary appointment.

Results and discussion

This section presents the situation during the COVID-19 pandemic, both for students and teachers, and compares it with the conditions prior to confinement.

Learning and ICT during COVID-19

After almost a year of effort by the ITCM professors to adapt to the new circumstance of the virtual teaching modality, the applied study among students showed that the MD used by the students for their courses were: 77% smartphone cell phone, 69 % laptop, 11% desktop, 2% tablet. 60% of the students used two or more DM.

The geographical location of the students was associated with their place of origin: 71% were in the ITCM location area; 12% in the north of Veracruz State, 3.5% in the east of San Luis Potosí State, and 3.5% in the center of Tamaulipas State. The latter located in smaller population centers and with less infrastructure facilities. Although 10% were also located in places further away from the ITCM.

About ICT

The essential connectivity for their courses came from: internet service at home (93%), mobile internet from cell phone (37%), internet service from their relatives (13%), internet from neighbors or friends (8%). Only 3% eventually went to a cyber-type pay-per-hour internet service, and another 2% obtained it from a public service available in some places.

The students expressed 82% satisfaction with the virtual modality, using ICT and their MD. In general, its biggest complication was the internet service, especially since the institutional Teams LMS is robust and demands a sustained bandwidth that, in many cases, not both students and teachers had. This meant that 58% of the time students were concerned about the sustainability of communication, and perhaps because of this the need to maintain contact with their teachers through private social networks such as WhatsApp.

However, something congruent with the pre-COVID-19 pandemic investigations is that 88% of the students resorted to videos on YouTube when they had doubts about the contents of their courses, while 67% chose to review their notes located in the institutional LMS, 64% reviewed the videos they had of class sessions or those that their teachers had placed in the LMS, 64% asked their friends from the same group, 61% searched Google, 34% contacted the teacher, and 26% asked another person outside the group.

About learning activities

The activities that students did with their teachers during their courses and that they liked the most are shown in Table 1.

#	Activities	Students
1	Online class recordings	66%
2	Videocalls in *Teams*	59%
3	Communication by *WhatsApp*	56%
4	Exams in *Forms*	46%
5	Teacher presentations	44%
6	Notes from the teacher in *Teams*	43%
7	Team presentations	42%
8	Team exams	35%
9	Work in pairs	28%
10	Internships or projects	28%

Table 1 Activities preferred by students

The general use of the tools associated with the institutional Teams LMS was considered very useful by the students (85%). Some resources were already used and were still present: Geogebra (20%) and Khan Academy (7%), but others broke in such as the digital whiteboard (19%), OneNote (13%) and even greetings and messages using emojis (19 %). New activities for this educational level such as quick tests in Kahoot had 26% of the mentions as attractive to them.

Learning activities were diversified with the Teams platform tools such as: tasks in the spaces for it (22%), research (20%), video production (12%), review of the homework at the beginning of class (12%) and evaluate other teams (8%). In this sense, the students considered that learning through these digital applications had been great (49%) and regular (35%). 7.3% expressed that it had been complicated.

The resources used for learning evaluation, the favorites by the students are presented in table 2. As can be seen, the evaluations through exams or Forms questionnaires and those carried out as a team are the best for them. Although, those short and quick exams in Kahoot, which were hardly used before, today have the recognition of the students.

#	Resource	Students
1	Exams in *Forms*	68%
2	Team exams	57%
3	Internships or projects	47%
4	Portfolio of evidence	36%
5	Quick exams in Kahoot	29%
6	Exams in pairs	25%
7	Problem presentations	23%
8	Personal exam in video call	12%

Table 2 Favorite student assessments

About personal situations

When the students needed help, just over half of them (53%) answered questions on their own, but some asked for help from another person as a friend outside the course (49%). Some never asked for help (20%).

Regarding their personal situation -physical or emotional-, half (49%) of the students felt very stressed, 30% suffered from anxiety at times, 22% suffered from depression, and 28% suffered from COVID-19 infection in them themselves or in their family environment.

Some students had to seek professional help due to stress (9%), and 5% underwent medical treatment for various reasons. Just over a third (36%) who answered the questionnaire stated that they had not had health problems.

Teachers and ICT during COVID-19

The first question asked to the teachers in the applied questionnaire referred to their situation at the beginning of the confinement derived from the COVID-19 pandemic, in March 2020. Some teachers found themselves in crisis and could not face the emergency swiftly, for which reason the conclusion of the school year was completely irregular for them (6%) and their students. However, the majority response (89%) was the continuation of their teaching work in virtual or distance format, with what they had or what they had improvised.

Those immediate responses included working with the LMS they already knew, such as Moodle or Schoology, others took the opportunity and recorded their classes in short videos that were uploaded to YouTube. Still others used applications, software, or simulators that they already had for their courses, although the problem arose that the students sometimes did not have the appropriate equipment. By the second semester of 2020, the teachers had already decided on their new teaching strategy and the technological resources they would use.

About ICT

Most of the teachers used more than one device to connect and attend their courses: 85% did it from a laptop, 26% from a computer. desktop and 26% from a smart cell phone, and only 11% from a tablet.

Teachers reported problems with their internet connection were that it was shared with other family members (33%) or that it was very slow (33%), due to power failures (25%), or because they sometimes had to travel to another place to have access (9%). Almost half (47%) said they had no problems with their internet service.

The teachers answered the doubts of their students basically using the group or individual chat of the institutional LMS (91%), although they also used the WhatsApp social network (58%) and email (54%). However, also 28% used personal telephone communications.

About teaching activities

The resources that teachers used the most during the studied period are presented in Table 3.

Even with all the available technology, the document in non-editable format is the most frequent, distributed by various ways, but it is the priority resource of teachers to share content, available in the files folder of Teams. Also, the non-marginal use of other means such as Zoom or WhatsApp to make video calls, although they had the Teams LMS, can only be explained if the problems of an unstable and weak internet service are considered.

#	Resources	Teachers
1	Non-editable files in Teams	87%
2	Video calls in *Teams*	84%
3	Teams Chat	78%
4	Slides presentations	56%
5	Online class recordings	55%
6	Own notes in images	50%
7	YouTube video links	46%
8	WhatsApp Chat	45%
9	Digital board	39%
10	OneNote App	24%
11	Previous class recordings	12%
12	Khan Academy Activities	10%
13	Activities in GeoGebra	10%
14	Teams Escape Room	9%
15	Video calls by other means	9%

Table 3 Resources used by teachers, always or almost always during the first semester of 2021

Students thanked that the teachers presented their class through slides (56%), or their own notes in digital images (50%), and the digital whiteboard (39%), or use the OneNote application in Teams (24%), and previously recorded class (12%). Although also, 10% carried out activities in Geogebra or assigned Khan Academy tasks, which include written documents, explanatory videos, and exercises to assess progress in students' skills.

Table 4 shows the teachers' strategies for learning evaluation. With a frequency ranging from a few times to always, the evaluation is preponderant over individual work with: practices written in the notebook, virtual exams and written, evidence portfolio, and oral exams. Evaluations on collaborative and cooperative work are mainly with presentations in front of the group, and group exams, although to a lesser extent. Also, 17% used recreational activities such as Kahoot for rapid evaluations, a resource that became attractive to students.

Evaluation strategy	Teachers
Practice in the notebook	77%
Exams in *Forms*	74%
Individual written exam	68%
Team exhibitions	62%
Portfolio of evidence	60%
Individual oral exam	35%
Team exam	32%
Quick test in Kahoot	17%
Exam in pairs	12%
Practice with GeoGebra	11%
Exams in Schoology	10%
Others	23%

Table 4 Assessment applied by teachers, always or sometimes, during the first semester of 2021

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In the same table 4, the last evaluation item includes the presentation of practices or projects with programming languages and simulators for various subjects, especially specialties. Also, the use of Moodle or Socrative for exams.

About teacher situations

In other types of problems in the courses, the teachers reported as the most important: apathy of the students (44%), lack of commitment or the work of the students (40%), absence of the students in the video calls (37%), high number of students in the groups (21%), and complications to connect to the LMS (20%).

Although also 37% of the teachers had no problems with their courses during the semester

About teacher training

Finally, in relation to the training received by teachers, Table 5 shows the most important ones. It is worth highlighting the importance of the self-taught character in two-thirds of the teachers, and the valuable support provided and received for the third part of the ITCM academics.

Training received	Teachers
Institutional courses (ITCM)	71%
Self-taught	65%
Microsoft courses	59%
Courses taught by the Instituto National Technological Institute of Mexico	54%
Teams diploma	40%
Advice and personal support from ITCM colleagues	33%
Courses at other institutions	18%

Table 5 Training received by teachers

The institutional effort, and of the central authorities, for the intensive and extensive training of teachers is evident with the wide coverage of the courses associated with the license acquired from the Teams platform. An additional element on this is the inclusion of pedagogical aspects in technological training. Students and teachers agree on the benefits of having video calls for class sessions, and their respective recordings.

The Microsoft courses presented a flexible alternative due to the diversity of routes in terms of the subject and the time required. The diploma on the Teams LMS and other associated applications allowed the rethinking and enrichment of teaching strategies focused on the virtual modality. Evidence of this are the resources such as the Escape Rooms for the collaborative work of the students; and the facilities of conducting research and projects using OneNote, for example.

Gratefulness

ITCMAD-15 Academic Team recognizes the cooperation and support of the professors and students who voluntarily answered the questionnaire to carry out this work.

Likewise, they appreciate the authorities of the National Technological Institute of Mexico for the facilities to access the Teams Diploma which strengthened the experience for the design of the instruments used for this research and the interpretation of the responses.

Conclusions

The health emergency conditions due to COVID-19 forced teachers to use ICT, the majority by themselves (94%). Students and teachers agree on the wide satisfaction they have for the LMS platform that the ITCM has. The above provided certainty in the environment for the teaching work, and if anything, rather the teachers complained about the demand for attention from the students throughout the day and the course.

After analyzing the description of the teachers' responses during this time of the COVID-19 pandemic, it is possible to affirm that, as Pedró (2020) said, *Coronateaching* made its appearance at the ITCM. The return to the lost normality was still waiting, but it is not over yet. However, the positive aspects of improvement could be highlighted in the face of the wide gap in digital, informational, and technological competences of most of the teachers, who were hired for the face-to-face modality.

Students recognize the benefits of having the materials and content for their courses, all in the institutional LMS, a situation that was not guaranteed in the face-to-face mode.

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Although the students mention that their teachers do not have the flexibility they would like, and that eventually they even take oral exams in a video call, on the other hand they find the exams in teams or in pairs very suitable.

This irruption of so many resources and strategies to carry out teaching activity has no going backwards. The following years will have to define new didactic models from these compulsory experiences. ITCM will have benefited from initiating a new era with a critical mass of professors with experience in this virtual modality.

One of the pending issues to investigate about this great social experiment that the COVID-19 pandemic became, is the evaluation of the deficit in cognitive and non-cognitive skills of students, mentioned by Di Pietro et al. (2020), it will also be a challenge to investigate it. Probably in a couple of years we will have the conditions to do it.

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Industry 4.0: The new educational paradigm?

Industria 4.0: ¿El nuevo paradigma educativo?

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Abstract

The leaps and bounds advance of technology has forced us to pursue new ways of generating knowledge that have an implication that goes beyond the classroom; It is as necessary to update our teaching-learning processes as it is to raise educational quality and power; You have to accept the idea that changes are achievable for everyone, but you have to bear in mind that the results or the idea of failure has no place in society where the demand is ever greater; That is why we need to constantly adapt to new processes that lead us to satisfy the needs of our environment; all this in order to contribute to our community, providing human potential according to professional and personal demands that include good management of soft skills, to improve people's consciousness and unity.

Objectives, methodology. The present work seeks to demonstrate that the new times handle a requirement in all areas of life, therefore, it is necessary to provide the best tools for students from educational establishments, it is perhaps in this way, that it can be included in gradually, procedures that allow them to acquire practical training, focused on the application of cases that help critical and abstract thinking; where one of the fundamentals is to allow to manifest new regulations that are integrated into the study plans and considerably increase the skills that are sought today every time a university degree is finished. That is why we consider it of great relevance that the knowledge received in the classroom, is attached to the requirements that are sought in the work part, all in order to contribute favorably to continuous improvement, yes, focused on educational facilities but outlined to the professional and labor side.

Contribution. This research has the purpose of showing that the professional needs to be covered in educational establishments must increasingly encompass a greater integrity, from the processes, activities and the required level of specialization; It is not only about complementing the knowledge with the use of another language, but also carrying out parallel studies that increase and diversify the knowledge of the graduate; all this in order to generate better competitiveness and reinforce progress and significant learning

Paradigm, Meaningful learning, Competitiveness, Process, Integration

Resumen

El avance a pasos agigantados de la tecnología, nos ha obligado a perseguir nuevas formas de generar conocimientos que tengan una implicación que va más allá de las aulas; es tan necesario actualizar nuestros procesos de enseñanza aprendizaje como elevar la calidad y el poder educativo; hay que aceptar la idea de que los cambios son alcanzables para todos, pero hay que tener en cuenta que los resultados o la idea de fracaso, no tiene cabida en la sociedad donde la exigencia cada vez es mayor; es por ello, que necesitamos adaptarnos constantemente a nuevos procesos que nos lleven a satisfacer las necesidades de nuestro entorno; todo ello con el fin de contribuir a nuestra comunidad, aportando potencial humano acorde a las exigencias profesionales y personales que incluyan un buen manejo de las habilidades blandas, para el mejoramiento de la conciencia y unidad de las personas.

Objetivos, metodología. El presente trabajo, busca demostrar que los nuevos tiempos manejan una exigencia en todos los ámbitos de la vida, por lo cual, es necesario otorgar las mejores herramientas para los educandos desde los planteles educativos, es quizá de esta forma, que se puede incluir de forma paulatina, procedimientos que les permitan adquirir capacitaciones prácticas, enfocadas a la aplicación de casos que ayuden al pensamiento crítico y abstracto; donde uno de los fundamentos, es permitir manifestar nuevos ordenamientos que se integren a las especialidades de los planes de estudio e incrementar considerablemente las habilidades que se buscan hoy toda vez que se termina una carrera universitaria. Es por ello que se considera de gran relevancia que los conocimientos que se reciban en el aula, estén apegados a los requerimientos que se buscan en la parte laboral, todo ello con el fin de contribuir favorablemente a la mejora continua, enfocada en los planteles educativos pero perfilados a la parte profesional y laboral.

Contribución. Esta investigación tiene la finalidad de mostrar que las necesidades profesionales a cubrir en los planteles educativos deben abarcar cada vez una mayor integridad, desde los procesos, las actividades y el nivel de especialización requerido; ya no solo se trata de complementar los conocimientos con el uso de otra lengua, sino además, el llevar a cabo estudios paralelos que eleven y diversifiquen el conocimiento del egresado; todo ello con el fin de generar una mejor competitividad y reforzar los avances y aprendizaje significativo.

Paradigma, Aprendizaje significativo, Competitividad, Proceso, Integración

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Introduction

At present, a person must not only have an individual vision of himself, since he is part of a community, he must focus on the fact that it is also necessary to identify himself as part of, as an important and necessary gear in practice and in the world work, that is of great importance, since it implies a constant reinforcement of all their capacities.

The old educational paradigm proposed that students should be prepared so that, every time their educational instruction was finished, their incorporation into society was already waiting for them, and the instructors in the classrooms had all the answers, mainly focused on to develop knowledge that would allow them to adapt to a work role based on criteria, memorization and discarding creative processes.

The new paradigm indicates that we must have a new vision of the student, recognize inherent talents and capacities, generating adequate spaces to recognize oneself from self-knowledge, allowing them to explore their aptitudes and abilities that generate adaptation to new work schemes; It is therefore that teachers, we must identify the type of intelligence, talents and qualities they possess and from there, include the use of soft skills that currently are also a fundamental part of the work process: teamwork, empathy , collaborative experiences, etc.

It is undeniable that new professional or job opportunities are getting shorter and shorter; A higher level of competitiveness must be shown, experience in the area and knowledge backed by diplomas and certificates that endorse them, this forces educational establishments to generate new proposals that include study programs focused on satisfying the needs of the "outside world ”, That is why research should be carried out that is focused on how viable is the diversification of higher-level studies, if there are sufficient mechanisms to face the new needs of the industry and society in general, and what is the impact at the student level of not carrying out this mission.

Industry 4.0

Economies are growing by leaps and bounds, which requires a diversification of processes and ways of carrying out activities in companies, one of the great fears that all societies have is that robots and data can make human beings replaceable ; Sensors are becoming a fundamental part of any process not only at the industry level, but also in our daily lives, these sensors provide us with data that allow us to manage information and mass storage that we can access anywhere and at a very low cost, bringing As a consequence, the use of Artificial Intelligence, that is, how these data extract organized information even better than the human brain itself to be able to apply it in practical solutions, at a lower price and in imperceptible times.

Figure 1 Collaborative robots
Source: (ielektro, 2021)

When we talk about industrial processes, we must go back to the First Industrial Revolution, which generated the change from manual work carried out by people supported by animals to work by the same people, but now supported by engines whose operation based on water vapor included tools very basic. The appearance of the Second Industrial Revolution, marks the advance with the use of electricity, which generated greater efficiency and dynamism by producing in mass, greater volume, greater profit.

The third Industrial Revolution allowed the incorporation of digital technology, beginning to incorporate automation software into its processes.

Industry 4.0 is then a new industrial reform, which implements interconnectivity, autonomous learning, automation and optimal management of data in real time in all its processes, products and people involved, starting from the IoT (Internet of the Things), allows the connection of the physical with the digital and companies are no longer seen as isolated environments or areas, better collaboration and access to all departments is taken as this allows increased productivity, improved processes and as a consequence, continuous and sustainable growth.

Pillars of industry 4.0

With the passage of time, we have seen how new processes and new techniques have been included when carrying out activities not only in organizations, but also in our daily lives, generating endless solutions for any situation we have, the Fourth Industrial Revolution, handles nine pillars or "supports" to generate highly technological solutions:

- BIG DATA AND ARTIFICIAL INTELLIGENCE. It allows the capture, compilation and analysis of large amounts of information, from different sources, all in order to reinforce decision-making, supported by Artificial Intelligence algorithms to make work more efficient, anticipate events that are not beneficial, reduce waste of material and optimize processes.

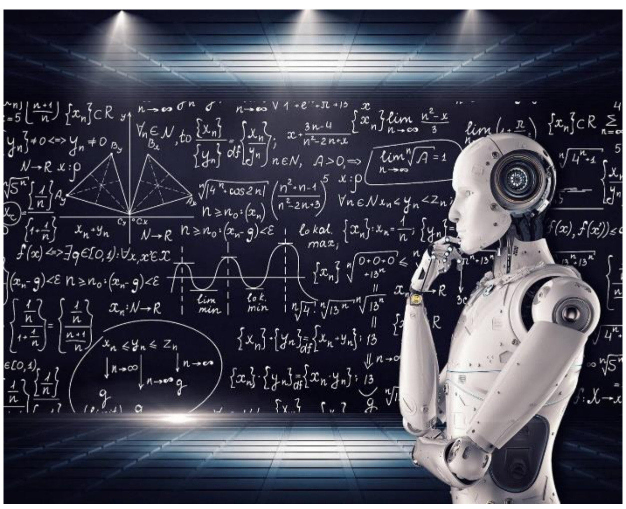


Figure 2 Artificial Intelligence
Source: (Digitization, politics and Artificial Intelligence, 2021)

- AUTONOMOUS ROBOTS. They are generated at a lower cost and with a greater capacity to generate solutions, in addition to the well-known human-computer interaction.

Figure 3 Robot
Source: (Digital Politics, 2021)

- SIMULATIONS. This type of "virtual testing" allows data to be grouped in real time in order to provide solutions before problems occur, helping to integrate all areas of the company and treating them as a whole.

Figure 4 Simulators
Source: (Technohighways, 2021)

- INTERNET OF THINGS (IoT). One of the most significant contributions of Industry 4.0 is undoubtedly the use of sensors and technologies that allow devices to communicate and interact with each other and with the individuals who manage them, once again allowing decision-making and real-time responses.

Figure 5 IoT
Source: (Electric Future, 2021)

- CYBERSECURITY. A very important aspect, since, from the processes and improvements in this area, all the information that runs in the different systems is protected.

Figure 6 Cybersecurity
Source: (e-Weekly, 2021)

- CLOUD. The exchange of data, which is increasing, must allow access to them, at any time and place, so the use of clouds is an almost indispensable aspect for Industry 4.0

Figure 7 Cloud Computing
Source: (redfibra.com, 2021)

- 3D MANUFACTURING. Additive printing is another very important factor, since it allows the generation of prototypes and improvement of various parts, at low cost and in a more sustainable way, since it avoids the waste of man-hours and materials immersed in the process.

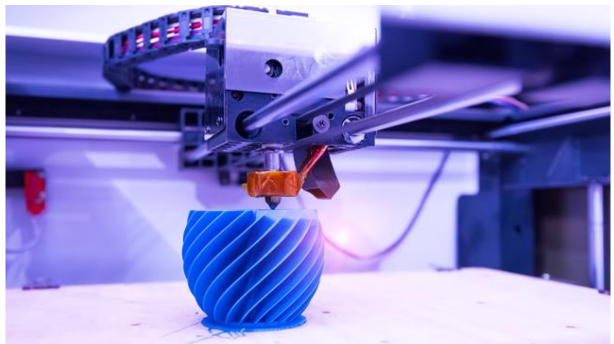


Figure 8 Additive manufacturing
Source: (elExportador, 2021)

- AUGMENTED REALITY. The use of multimedia is very close to developing content that provides information in real time and improving any process based on the reality perceived by people with the use of accessories prepared for this purpose.

Figure 9 Augmented reality
Source: (hubspot, 2021)

Advantages of including industry 4.0 in the educational plan

We have been observing all the aspects that are related to or comprise industry 4.0, at an educational level, we must find what of the model fits and what aspects can be reinforced or even get a better version of the knowledge and training at a higher level, the primary exercise here is to know RE-KNOW what are the elements that are needed to effectively contribute to generating strategies to raise education, here are some steps that can contribute to optimizing this process:

1. LOCATE THE NEEDS OF THE ENVIRONMENT (how to strengthen the community).

2. GENERATE APPROACH AT THE BUSINESS LEVEL ON WHAT WORKS ARE CARRIED OUT (what kind of knowledge is necessary for graduates to have).

3. ANALYZE THE STUDY PLANS AND IDENTIFY WHETHER YOU SHOULD WORK ON THE ENTIRE STUDY PLAN OR ONLY ON THE AREA OF SPECIALTY (depending on the areas of opportunity that are had when the student finishes their studies).

4. RAISE AWARENESS AND TRAIN THE TEACHING STAFF ON NEW TOOLS APPLICABLE TO THE TEACHING-LEARNING PROCESS (constant growth by the instructors will ensure continuous quality).

However; Being able to make significant changes to the study plan offers us the possibility of:

a. PROVIDE SIGNIFICANT KNOWLEDGE TO THE EDUCATOR. By working with the knowledge in vogue, significant contributions are obtained from outside the educationnal establishments

b. GENERATE CHANGES IN THE BUSINESS AREA THAT BENEFIT THE ESTABLISHED PROCESSES. Talking about competitiveness refers us not only to a local and national level, but also to a global level, that is why, by being part of companies that work with some pillar of Industry 4.0, it allows us to establish jobs that confront us with other people who , even if they are not physically close, if they can be direct competition in the work that is done.

c. DESIGN THE EDUCATIONAL PLANTS AS REAL TRAINING OPTIONS FOR THE INDUSTRY. Currently, companies invest large resources in training their staff with new technologies, with this, HEIs can be a reliable option to promote specialization courses for organizations' staff.

The needs of companies vs knowledge of expenditure

For HEIs (Higher Education Institutions), it is of utmost importance that the study plans impact on the needs and problems that companies currently have in their day to day and even more so with the 4th. Industrial Revolution; For this reason, this research has as its main axis to analyze the needs of the company against the knowledge of the graduate, this with the aim of verifying if the study plans are sufficient or it is necessary to update the specialty, since as mentioned previously, it is of It is very important to be aware as IES, of the needs that arise in companies in relation to Industry 4.0, since it is very helpful in companies, without neglecting the professional experience that students must have, therefore, in the IES in the last semester, students take professional residencies, where the student goes to a company in which a project focused on the career is assigned and from which they can have a professional experience approach, landing the theoretical concepts of the career according to your study plan and specialty you have.

Methodology to be developed

The research focuses on the needs that currently exist in the company with respect to the integration of Industry 4.0 against the study plans that are still being worked on in the HEIs, all this in order to check if the tools acquired by students are enough to compete in the industry.

This research is supported by the qualitative and experimental method, taking as a sample one of the technological careers called Engineering in Technologies, which is offered at the IES.

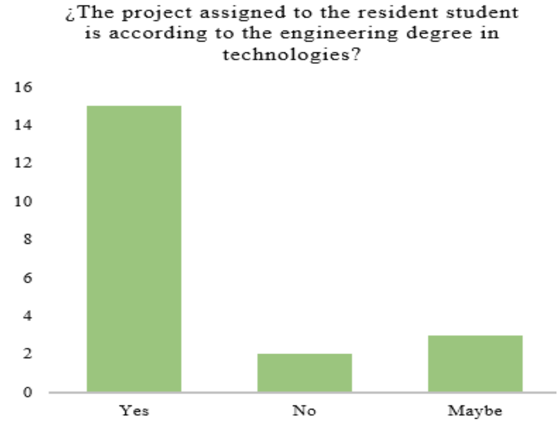
It began by applying a survey to companies, in which students of the Engineering in Technologies career were studying professional residencies, said survey was divided as follows:

- The first part is to know if the type of project assigned was to end the study plan of the Engineering in Technologies career.
- The second part was to find out if the projects that the company is working on and assigned to residents had any relationship with the pillars of Industry 4.0.
- The third part aims to analyze whether the student's knowledge acquired throughout the career was good, sufficient or deficient to be able to develop the project and / or various activities that he is in charge of..

Next, in graph 1, shows the results of the first part of the survey, where it can be seen that indeed the projects assigned to students are mostly in accordance with the study plan of the Engineering in Technologies career, encouraging that students are not alien to the various tasks that have to be developed for the project.

1. **Does the project assign to the resident student, is it according to the Engineering in Technologies degree?**

Yes	15
No	2
Maybe	3

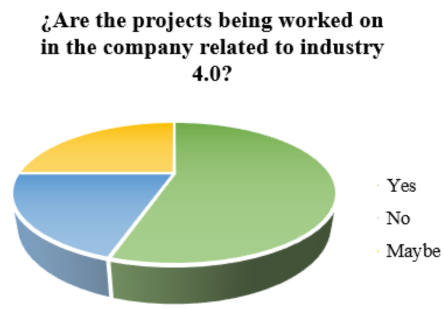


Graphic 1 Project assigned by the company
Source: Own elaboration

Now in Graphic 2, the results on the relationship that the projects managed in the company have with some of the pillars of Industry 4.0, which is observed that the majority of companies surveyed do have projects related to Industry 4.0 ; In turn, Graphic 3 shows in which pillar these projects are related, where it is observed that in the majority there is a relationship with the Internet of Things (IOT) pillar of Industry 4.0, since companies refer to a digital interconnection with everyday objects. Finally, Graphic 4 shows the results on the assignment of these projects to students, which we see is even since 45% do assign it to resident students while the rest do not, this being a point of alert since it would be convenient to know the reason why it is not assigned.

2. **¿Are the projects being worked on in the company are they related to Industry 4.0?**

Yes	11
No	4
Maybe	5



Graphic 2 Projects worked with Industry 4.0 relationship
Source: Own elaboration

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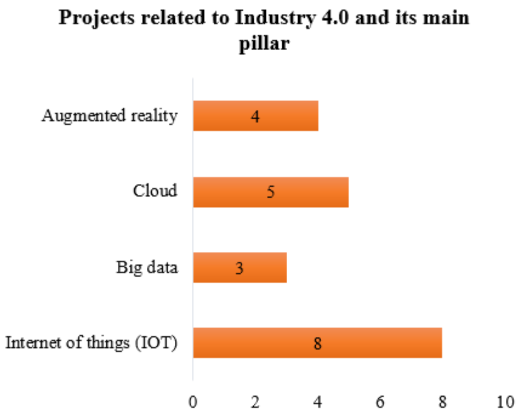
3. ¿Are projects related to Industry 4.0 which pillar do you focus on?

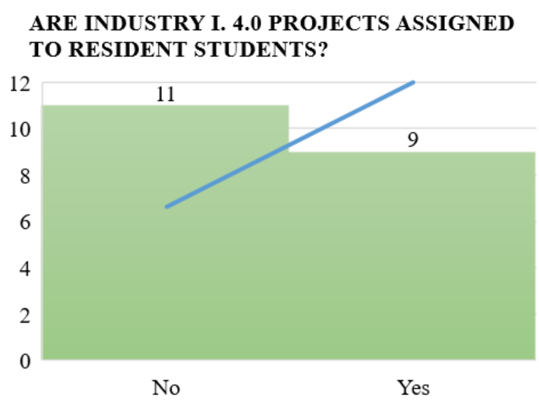
Internet of Things (IOT)	8
Big data	3
Cloud	5
Augmented reality	4



Graphic 3 Projects related to Industry 4.0 and pillar
Source: Own elaboration

4. ¿Are projects of this type assigned to students' residents?

Yes	9
No	11

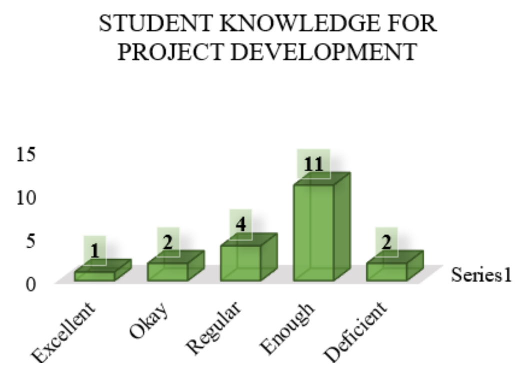


Graphic 4 Assignment of projects related to Industry 4.0 to resident students
Source: Own elaboration

Lastly, in the third part of the survey, and no less important, it can be shown in graph 5 that companies evaluate the knowledge acquired by students throughout the career as sufficient, since, in observations they mention who are unaware of certain techniques and / or technological tools that impact on the development of the project and of which are related to Industry 4.0.

5. How do you evaluate the students' knowledge acquired throughout his career help the development or appropriate use of new technologies in industry 4.0?

Excellent	1
Okay	2
Regular	4
Enough	11
Deficient	2



Graphic 5 Knowledge acquired by students for the development of projects and also related to Industry 4.0
Source: Own elaboration

According to the results of the survey, we can observe that when comparing the needs of the companies against the study plan of the career taken as a sample, they do not go hand in hand at 100%, since it is important that the students are trained with the current tools so that they have a great competitiveness, since the knowledge acquired in the classroom is not entirely attached to the labor needs.

Results

It is very true that currently students have to have a broader vision inside and outside the classroom, motivated by meeting needs in professional and work life, in turn HEIs have to adapt to these new needs, since The objective is for companies to employ graduates and at the same time cover the needs they have today. This research manages to make a comparison between the knowledge acquired by students in the classroom, against what companies require, since in the surveys carried out they show that 75% of companies are focused on the use of new tools that allow streamline processes or that are focused on some pillar of Industry 4.0, which indicates that it is increasingly important for HEIs to be in constant communication and link with companies, since in this way it is possible to detect the new needs that exist to that can be covered in the classrooms offering educational quality to students, all this would take place by adapting the specialty of the study plan to the new needs that companies have.

The result is also verified that companies are working collaboratively to improve their productivity, all this with the help of Industry 4.0 and its pillars, having as an impact a sufficient but not excellent knowledge on the part of the students, which should encourage HEIs to prepare both with the teachers and with the updating of the laboratories.

What is a certainty is that it is becoming more and more evident to have to match study programs to the needs of companies, so that Industry 4.0 becomes a leading tool from which to start work effectively, thereby achieving that students leave better prepared and are more empathetic to the environment they are inserted.

Acknowledgments

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Conclusions

The research shows that companies have a need that is not covered 100% with the study plans offered in HEIs, since currently the projects that are being worked on in the workplace are focused on new tools technologies that offer the pillars of Industry 4.0, since today the main tool is to be able to work collaboratively, because it leads to improving processes that previously took more time, and having better connectivity with projects that interact with the IoT , this being one of the pillars in which they develop the most and in which students are not yet trained.

With the above result, it is proposed that HEIs have greater links with companies, and training programs for teachers and implementation of specialized laboratories in the areas of Industry 4.0, so that together with the updates of the specialty of the curricula offered in the various careers, it is possible to meet the educational quality of the graduates and in turn with the satisfaction of the companies that ultimately support the graduates to have professional experience.

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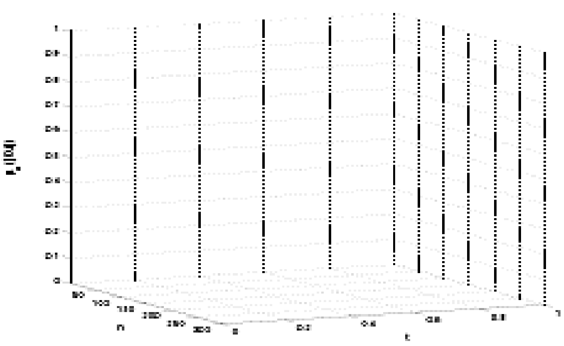

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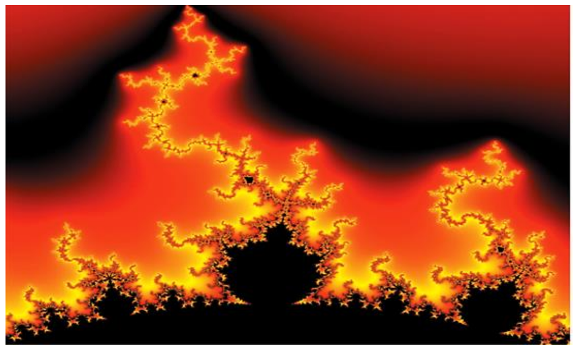

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