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Journal Practical Didactics

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Presentation of Content

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App Per-Q Teponaztli: Innovation for rhythmic music education

App Per-Q Teponaztli: Innovación para la educación musical rítmica

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Abstract

The following article presents the Per-Q Teponaztli mobile application as an innovation proposal for music education. Per-Q Teponaztli is a complementary tool of Per-Q, a rhythmic musical training program for children between 7 and 12 years of age implemented in virtual learning environments and based on different rhythmic musical learning methodologies that promote the development of multi-functional skills. and intercultural. The design and implementation process of the application was carried out through the agile SCRUM methodology. Developed for the Android environment, Per-Q Teponaztli consists of a virtual representation of a teponaztli, a percussion instrument originating in the pre-Hispanic period in Mexico. The direct interaction of the instrument in virtual format through a digital device allows for its implementation of gamification dynamics and game elements mediated by technology, favoring the appropriation of multicultural skills and an approach of students to the musical roots and traditions of our country.

Musical learning mobiles apps, Gamification techniques, Multiculturalism in musical learning, Intercultural environments

Resumen

El siguiente artículo presenta la aplicación móvil Per-Q Teponaztli como una propuesta de innovación para la educación musical. Per-Q Teponaztli es una herramienta complementaria de Per-Q, programa de formación musical rítmica para niños de entre 7 y 12 años de edad implementado en ambientes virtuales de aprendizaje y basado en diferentes metodologías de aprendizajes musicales rítmicos que fomentan el desarrollo de competencias multi e interculturales. El proceso de diseño e implementación de la aplicación se realizó a través de la metodología ágil de SCRUM. Desarrollado para el entorno Android, Per-Q Teponaztli consiste en una representación virtual de un teponaztli, instrumento de percusión originario del periodo prehispánico en México. La interacción directa del instrumento en formato virtual a través de un dispositivo digital permite en su implementación dinámicas de gamificación y elementos de juego mediados por la tecnología, favoreciendo la apropiación de competencias multiculturales y un acercamiento de los alumnos a las raíces y tradiciones musicales de nuestro país.

Apps de educación musical, Técnicas de gamificación, Multiculturalidad en aprendizajes musicales, Ambientes interculturales

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Introduction

Per-Q is an online rhythmic music teaching programme for children between 7 and 12 years old, of which a first pilot module will be implemented during the summer of 2022 through the Google Workspace platform. The programme is based on different rhythmic learning methodologies where play and improvisation are common elements, considering its implementation in virtual environments with the mediation of digital tools and Information and Communication Technologies (ICT). The Per-Q programme integrates the product "Per-Q Teponaztli" to generate gamified activities as part of an educational innovation strategy. The concept of gamification is defined as "the use of game elements and game design techniques in non-game content" (Werbach and Hunter, 2013) and has been integrated as part of new trends in educational techniques, having as one of its main objectives the acquisition of knowledge through fun and enjoyable learning experiences, leading students to enjoy and become more involved in their learning process.

The teponaztli is a percussion instrument originating from pre-Hispanic Mexico (the instrument, as it is known, dates from the Mesoamerican post-classical period, between 800 and 1000 AD. - 1521 AD). Mexico has a great musical cultural wealth and the programme is a means of bringing new generations closer to its culture. The virtual representation of a musical instrument allows users to learn about and interact with instruments that may be considered unconventional and to experience their performance in an accessible way.

One of the main methodologies of the project is the Dum-Dum Programme by Santiago Pérez- Aldeguer, which, in addition to having game dynamics, has among its objectives the development of multi- and intercultural competences in students. For Pérez- Aldeguer (2014) inclusive education is "the set of principles that ensure that the student, regardless of their characteristics, is a valuable person". Multiculturalism refers to the presence of several cultures in the same society, and "assuming it means recognising the right to difference as an educational and social enrichment" (Imbernón, 2000).

From a multicultural approach, music can be used as a pedagogical resource that fosters the acceptance and recognition of cultural diversity.

Another of the project's core methodologies is "How to play", a series of rhythmic learning methods for percussion created by Alan Dworsky. Among the methods is Slap Happy, which focuses on rhythmic musical performance with body parts and allows students to experience playing world rhythms without the need to acquire an instrument. While children are learning the rhythms, they will be developing coordination, concentration and cooperation (Dworsky, 2002).

The basis of the methodology is the performance and creation of rhythms without the need for a musical instrument. Rhythm can be executed by body movements or even everyday objects can be used to produce rhythms or even to make one's own instrument. The Slap Happy method provides accessibility options that can be adopted as part of the programme's philosophy: there are no limits to the rhythms that can be played, they can be made with one's own body, with everyday objects and with free downloadable digital applications.

The development of specialised music software has gone hand in hand with the evolution of digital technology. The video game format has given these music creation and production tools the entertainment element of the game itself and the different interaction dynamics that support the concept of gamification. According to Miller (2013), these games have made it possible to generate new approaches to aspects such as composition, performance, pedagogy and musical appreciation, which has contributed to the development of creativity and entrepreneurship.

Gamification as an educational technique is based on different theories that respond to the way in which people interact when they are involved in a game experience. The theories of motivation, self-determination and goal achievement help us to understand what motivates the participants of a game in their interest to achieve objectives and to be participants in an activity where competition is implicit.

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The behavioural paradigm is present in the dynamics of video games and justifies many of the characteristics of gamification techniques. Skinner's behavioural theory establishes the term reinforcement, which refers to the reward for a certain behaviour (Hernández and Mateos, 2021). The stimulus-response factor is reflected in gamified activities with the establishment of measurable and observable objectives.

Another theory associated with gamification and present in the application is cognitivism, which "emphasises what happens in the learner's mind when learning happens" (Ahmad et al, 2019, p. 3). The Per-Q programme to which the app belongs is aimed at children between the ages of 7 and 12, which corresponds to the stage of concrete operations established in Jean Piaget's theory of cognitive development: from these ages onwards, symbols are manipulated logically and systematically, connecting to concrete objects (Ibidem, p. 4).

For Piaget (2016) "concrete operations constitute the transition between action and more general logical structures involving combinatorics and a "group" structure. Classification and seriation allow an understanding of the order of rhythm, both in the steps to execute it and to structure it. The notion of numbers from the perspective of seriation and the understanding of space, time and speed allow the rhythmic sense to be captured not only by repetition, and where the visual representation helps as a reference to develop a rhythmic musical idea.

Within the dynamics of use of the application and its gamification elements, constructivism is present, which emphasises that students learn by constructing knowledge and meaning based on their experience (Schunk, 2012). The subject constructs knowledge of reality, since this cannot be known in itself, but through the cognitive mechanisms available to them, mechanisms which, in turn, allow transformations of that same reality (Araya, et al, 2007). Students are active in their own learning processes; it is not just about following instructions and understanding them, it is also about developing learning through experience and experimentation.

The development of the mobile application was carried out using the agile SCRUM methodology, which allowed revisions, adjustments and implementations to be made with each of the actors, including music teachers, software developers, graphic designers and editors.

This application allows to generate actions to bring children closer to the cultural features of Mexico through gamification and graphic and musical elements that are attractive to them, generating through the game the interest and motivation to learn with the use of technological tools.

Metodology

The development of the project from the conceptual level began in 2020 through a research-intervention project in the postgraduate course in Learning Management in Learning Environments of the Virtual University System of the University of Guadalajara.

The design and development of Per-Q Teponaztli is based on applications that represent musical instruments virtually. Regarding the percussion instruments section, there is a wide variety of applications such as Drum Kit (drums) or Shakers (maracas and minor percussions) where by means of touch contact with the screen or the movement of the device itself, the simulation of playing the instrument is produced. There are also percussion applications from different parts of the world such as Djembe Pad, Taiko Sounds or TimbalApp, but so far no application has been developed for a percussion instrument originating from pre-Hispanic Mexico.

The recognition and identification of the needs, the problems presented, the cause and effect relationship, as well as the analysis process derived from the interpretation of the data, made it possible to establish the lines of action and the work plan for the development of the Per-Q Teponaztli mobile application as an element that integrates the Per-Q programme and that, through gamification, aims to develop rhythmic skills, but also to promote a cultural approach.

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The technological development was carried out during two semesters between 2021 and 2022, starting with the determination of the SCRUM development methodology for its implementation, considering the elements of change and the multidisciplinary team composed of software developers, music professionals, graphic designers and editors.

This development methodology establishes a fundamental base that integrates partial or scaled deliveries in a continuous way, allowing the production process to be carried out in a more agile and rapid way. Within this methodology there are three profiles or roles with specific responsibilities that make up the work team during the development of the project: the project owner, who establishes, defines and guides the general objective of the project, as well as the specific ones, and is the one who generates the control, verification and follow-up actions of all the project activities;

There is also the SCRUM expert (SCRUM Master) who foresees, controls and solves the risks and problems that arise during the entire production and development cycle with all the members of the work team, and finally there are all the members of the SCRUM team, who are the rest of the people who collaborate in the activities and moments of the development and implementation. This methodology, according to DIMES (2015), establishes the development of activities and work in small or short iterations or cycles, which are also known as Sprints, which allows to have products or functionalities, thus being the ideal methodology for the development of projects or incremental solutions in the creation of solutions where requirements may undergo frequent changes, this implementation integrated the phases of analysis, design, development and testing.

Analysis

This is the initial phase of the development process and consisted of the creation of the product stack (Product Backlog), a fundamental document that integrates the information collected for its analysis, which was classified and categorised, thus allowing the establishment of the requirements that comply with the functionalities and tasks to be carried out.

The data collection was carried out, first, through interviews with various professionals in music pedagogy on the use of digital technologies in music teaching and the implementation of the established rhythmic methodologies. Likewise, the necessary parameters were defined for the conceptual development of the functionalities that should be present in the solution from the user's perspective. Subsequently, working sessions were held with the development team, which contributed to the conceptualisation of the functionalities from the system's perspective, and with this, the functional and non-functional requirements of the project were specified.

The requirements specification was based on the template of the IEEE Std 830-1998 standard of the Institute of Electricals and Electronics Engineers (IEEE, 1998). From this document, the definition of the product perspective and its functionality was proposed, in such a way that user characteristics, assumptions, restrictions and dependencies were determined, as well as the possible evolution of the project. The following is a description of some specific requirements of the ERS:

Requirement number	R1.02		
Requirement name	Open start menu		
Type	☒ Requirement	☐ Restriction	
Source of the requirement	Interview 12/09/2021, log 02		
Priority of the requirement	☒ High/Essential	☐ Medium/Wanted	☐ Low

Requirement number	R1.09		
Requirement name	Load instrument images		
Type	☒ Requirement	☐ Restriction	
Source of the requirement	Interview 12/09/2021, log 05		
Priority of the requirement	☒ High/Essential	☐ Medium/Wanted	☐ Low

Requirement number	R3.07		
Requirement name	Playing the instrument's sounds		
Type	☒ Requirement	☐ Restriction	
Source of the requirement	Interview 18/09/2021, log 03		
Priority of the requirement	☒ High/Essential	☐ Medium/Wanted	☐ Low

Table 1 *Specification of requirements*
Own Elaboration

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After defining this document, the Sprint Backlog was drawn up, in which the actions, times and resources to be carried out were defined. In addition to the assignment of tasks and the SCRUM team responsible for monitoring, the times and execution of each task were defined very precisely, for which Gantt and PERT charts were developed.

The specification of the Sprint provides the necessary elements to carry out the integration tests under an incremental model, in addition to the development of the meetings (Daily SCRUM), which were scheduled on a weekly basis according to the schedule of each of the team members. In this way it is possible to integrate the management of the risks detected in the development process.

Design and development

This phase includes the architectural and semantic design of the metadata, as well as the generation of all the audiovisual material required by the application in accordance with the established requirements and functionalities.

The development determined by functionalities and established for an incremental model allowed the definition of the system modules that are proposed from the Unified Modelling Language (UML) for the static and dynamic modelling of the system, considering the determination of the class or component diagram in which the elements that make up the solution were determined, considering attributes, methods and relationships, specifically in the elements that establish communication and send-receive messages or objects. In the same way, the design of the use cases was developed from a graphic model, with special emphasis on the interactions and triggers through the actors, to the definition of the processes, and the links that exist between the entities.

The development of the audiovisual material began with the graphic design of the teponaztli, which corresponds to the image and visual identity of the Per-Q programme, aimed at a children's audience, so the graphic line was at all times developed under a design criterion of material for children, presented below:

Figure 1 Design of teponaztli
Own Elaboration

In the same way and congruent with the functionality of the application with respect to the real or physical instrument, the recording of the real sounds of the instrument was made, reproducing the notes of G (left reed) and C (right reed). A third sound is reproduced in the application in the lower central part, represented in the drawing as a Q carved in wood. Its sound is the note of G at a higher pitch than the reeds. The following picture shows the description of the notes in the design:

Figure 2 Sounds of teponaztli
Own Elaboration

The application development process was carried out using Unity, which is considered to be a video game engine, also known as a game engine, which is a development environment that has a series of programming routines for the design, creation and operation of an interactive environment. Unity is cross-platform and allows development for operating systems such as Windows, Mac OS and Linux. The development environment with the project that was created is shown below:

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Figure 3 Project environment
Prepared by the author

The development of the solution required the configuration in specific spaces for the functionality of the game. Below is the image of the allocation of sounds in delimited spaces, corresponding to the tabs and the engraving of the letter Q at the bottom centre:

Figure 4 Allocation of sounds in delimited spaces
Own Elaboration

The construction of the application and the combination of the programmed actions or routines associated with multimedia resources made it possible to have a catalogue of resources for the development of the project. Below are the assets (resources) most used for the development of the project, which were mainly audio files .wav (recorded sounds of teponaztli) and image files .jpg (images of the app), which are shown in the following image:

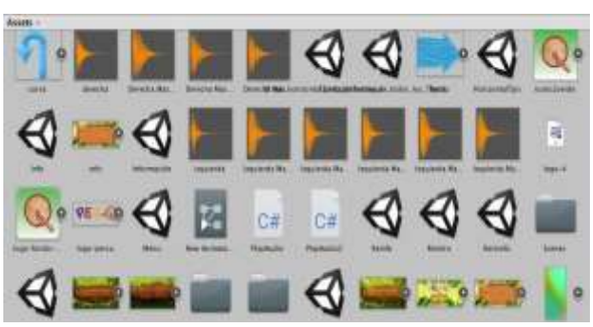

Figure 5 Project resources
Own Elaboration

The design and construction of the application based on the user experience and the gamification approach allowed to establish that routine or route of the scenes of the application, thus generating a storyboard or script that links and ties together all the scenarios and modules of the application. The following image shows the linking of the scenes of the application:

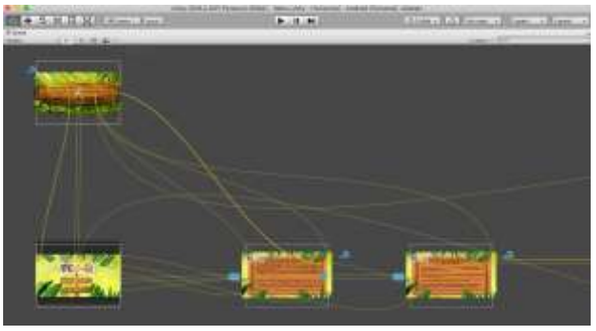

Figure 6 Scenes from the application
Prepared by the authors

Testing

At the end of the development of the application, the installation and testing process applied to the functionality of the system was carried out. This was carried out by means of a verification tool for the review and processes that will validate the technical (functionality), visual (graphic design and multimedia) and integration (linking scenes) aspects. The icon of the application installed on a mobile device is shown below:

Figure 7 Icon of the application
Own Elaboration

The start of the application as the initial pop-up window in the start-up process contains the visual identification of the project, which is presented as the application start-up window shown below:

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Figure 8 Start-up design of the application
Own Elaboration

Once the process has started and the player is ready to start the game, the image or menu is loaded from which the user controls the operation of the instrument. This main menu has two options: the information section, which describes the instrument and its characteristics in detail, and the to play section, which presents the image of the instrument with the aforementioned characteristics. It is from here that the user interacts with the virtual instrument by touching the screen of the mobile device with his fingers. The screen is presented below:

Figure 9 Menu of the application
Own Elaboration

The information section is made up of 3 windows or scenes that have the purpose of sharing information about the origin and characteristics of the instrument and in one of the windows the bibliographical references are presented. The following images correspond to the scenes that make up that section:

Figure 10 Information scene 1
Own Elaboration

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Figure 11 Information scene 2
Own Elaboration

Figure 12 Information scene 3, bibliographical references
Own Elaboration

The app has features of behaviourism in its implementation: the instruction and tracking of its outcomes, also present in a variety of video games, as well as the idea of both classical conditioning, which states that behaviours can be conditioned by providing repeated stimuli, and operant conditioning, behaviours are reinforced by the rewarded response (Ahmad et al, 2019, p. 3).

The element of motivation and goal achievement is identified, which also expands the dimensions of the outcome: an intangible reward or an intrinsic reward, where "the individual does not look at the consequences, he acts for the action itself" (Borrás, 2015), which in this case is learning about a musical instrument that he probably does not know and the possibility of playing and creating rhythms through the application.

From the pedagogical perspective of constructivism, the learning process is active. The user's experience of interacting directly with the application from their device allows them to get to know a different instrument, to know what its shape is like and how it sounds. The interaction allows them to experiment with its timbres and play with the rhythmic possibilities, which leads to improvisation and creative development.

Results

During the first months of 2022, the initial implementation tests were carried out, which allowed us to detect areas of improvement in the application and to make the corresponding adaptations to ensure its functionalities.

The first tests correspond to a review of the functionality of the application from a technological perspective. The application was installed on various smartphones with an Android operating system by the project team. The application is successfully installed on the selected operating system, can be opened and effectively plays both the scene sequences and all the corresponding images and sounds. To reinforce the review of the app's functionality, support was requested from people external to the product development to install the application on their Android devices. The results were the same as in the previous tests.

Likewise, after the technical review, it was necessary to evaluate the implementation of the app in the target audience and thus identify the fulfilment of the objectives established with a focus on gamification and the achievement of multicultural competences, for which an open questionnaire was designed as an evaluation instrument that was applied in person to children in the Guadalajara Metropolitan Area.

The results show conclusive information about the implementation of the application and the knowledge acquired from the approach of the gamification technique and the development of multicultural competences. 100% of the respondents considered the application to be fun and to simulate a gaming experience. The vast majority showed great interest in the teponaztli instrument, finding it fun and interesting to learn about old or "unfashionable" instruments. Although more than half of the participants responded in the survey that their main learning experience was learning about the instrument, there were also responses regarding the use of the app to generate and play rhythms. The use of the app by the participating children also aroused in them a curiosity to learn more about old instruments and an interest in acquiring and downloading the app.

With the results obtained in terms of the technological approach and the implementation of the app as a tool for gamified activities, Per-Q Teponaztli was registered in the Android download shops, specifically in the Play Store platform. The application will be available for free download in the second half of 2022, coinciding with the implementation period of the first module of the Per-Q programme..

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To the application development team: Daniel Watson, programmer, and Samuel Lozano, graphic designer.

To Maestra Paola Mercado Lozano, coordinator of the Master in Learning Management in Virtual Environments of the Virtual University System of the University of Guadalajara.

To Maestro Ernesto Cano Lomelí, Master in Musical Sciences, ethnomusicologist, composer and researcher.

Conclusions

Through the SCRUM methodology and its respective tests in the development of the app, as well as in the application of the functionality evaluation instrument, it can be determined that the Per-Q Teponaztli application has a viable use as a digital didactic tool.

The SCRUM methodology allowed for an agile and orderly development process. The determination of the roles in the work team together with a work plan monitored from a punctual follow-up achieved a professional and systematised process, where objectives were met based on established dates.

The objective of virtually representing the teponaztli instrument was successfully achieved by being able to replicate its aesthetic and acoustic characteristics through images and sounds. Based on the project's image identity and the target audience, the design of the drawing of the instrument is kept within the same graphic line without leaving aside the physical qualities of a real teponaztli.

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From a review of functionality, the tests carried out in the process give evidence of an application developed adequately for its operation: the app is easy to install on the devices for which it is programmed, its menus and scenes open smoothly and present an interface that is easy to navigate. On the other hand, the performance of the instrument in its virtual interaction is appropriate to the characteristics of the instrument both in its timbres and its sound body, and the app responds to touch in the right places and with the real sounds of a teponaztli.

The informative part within the app is presented as an added section that complements the learning and experience of knowing and interacting with the percussion instrument with information about its characteristics and origins, so that the complementary section reinforces the objective of developing multi- and intercultural competences and a complete and documented approach of the users to the musical traditions of our country.

Tests of the use and impact of the application with children demonstrate its effectiveness as an attractive tool for the public and whose characteristics allow for fun, enjoyable and accessible learning dynamics. The application manages to generate a gaming environment, so its use is supported as part of a gamified strategy. From a pedagogical perspective, the use of the app presents in its implementation characteristics of the various paradigms and theories of learning on which gamification is based: the theory of motivation, behavioural theory with the element of reinforcement, cognitivism, reflecting rhythmic learning from concrete operations, seriation and classification, and constructivism where the participant constructs and develops learning through their own experience and action.

On the other hand, the application finds in its implementation aspects of the basic methodologies of the project. Following the philosophy of Slap Happy, Per-Q Teponaztli allows users to make and develop rhythms without the need for musical instruments, which constitutes an innovative proposal where mediation through digital devices is presented as an alternative to achieve musical learning in an accessible way.

In the case of the Dum Dum programme, multicultural competences are present in the use of the application as a tool that fosters cultural identity and as a bridge for new generations to learn about the musical diversity and history of Mexico.

In conclusion, the Per-Q Teponaztli proposal, as a complementary tool to the Per-Q programme, is presented as a viable and appropriate option for the characteristics of the programme and its objectives, as well as the competences implicit in the project. The tests demonstrate the functionality of the app from the technological and pedagogical perspectives, so that it meets the requirements to be released as soon as possible for free download and be available in the implementation of the first module of the programme, in the second half of 2022.

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Comparative analysis of the Khan Academy virtual college course to improve new students' academic performance in Faculty of Engineering

Análisis comparativo del curso propedéutico virtual en Khan Academy para mejorar el desempeño académico en estudiantes de nuevo ingreso en Facultades de Ingeniería

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Abstract

The low performance of the engineering student is an underlying problem in mathematics subjects, derived from the various situations that surround the student and for which he is exposed to school dropout. However, there are technological learning tools (Khan Academy), which, if well implemented and in a timely manner, at the beginning of their higher education, help to improve the understanding of mathematical and logical concepts in the field of basic sciences and mathematics. especially in the latter, because it contributes greatly to the formation of the Engineer. The comparative analysis of the Virtual College Preparatory Course implemented in the Khan Academy platform over a period of 4 years was carried out, which shows the evolution of the new student, as well as the results with the comparative analysis of the diagnostic and final exam obtained each year. It is notorious reservation of young new students to make use of the various educational platforms on the Internet, however, the comparison suggests a positive impact by the use of these, with the appropriate guidance and experience.

College preparatory course, Khan Academy, Mathematics, E-Learning

Resumen

El bajo rendimiento del estudiante de ingeniería es un problema subyacente en las materias de matemáticas, derivado de las diversas situaciones que rodean al alumno y por lo cual se encuentra expuesto a la deserción escolar. Sin embargo, existen herramientas tecnológicas de aprendizaje (Khan Academy), que bien implementadas y de forma oportuna, en el inicio de su educación superior, coadyuva para mejorar la comprensión de los conceptos matemáticos y lógicos en el ámbito de las ciencias básicas y matemáticas, especialmente en esta última, por que contribuye en gran medida a la formación del Ingeniero. Se realizó el análisis comparativo del Curso Propedéutico Virtual implementado en la plataforma Khan Academy en un periodo de 4 años, lo cual muestra la evolución del estudiante de nuevo ingreso, así como los resultados con el análisis comparativo del examen diagnóstico y final obtenido cada año. Es notoria la reserva de los jóvenes estudiantes de nuevo ingreso hacer uso de las diversas plataformas educativas en internet, no obstante, la comparación sugiere un impacto positivo por el uso de estas, con la guía y experiencia adecuada.

Curso propedéutico, Khan Academy, Matemáticas, Aprendizaje virtual

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Introduction

When students start a new educational level mathematics teachers receive them with uneven knowledge in this area, which were provided in the immediate previous level (Díaz-Perera, Luna-Flores, & Salinas-Padilla, 2019), example of this, is the great diversity of public and private schools in the upper secondary education level, this has a direct impact on the different ways in which educational programs are approached, the lack of homogeneity in knowledge and good independent study habits by students, contributing in a high heterogeneity (Aguirre-Jones, 2020), which affects students in their first semesters in Higher Education Institutions (HEI).

Studies conducted on the decrease of such knowledge show the increase in failure rates mainly in the first semesters in HEIs (Gómez, 2011) (Petríz-Mayen, Barona-Ríos, López Villareal, & Quiroz-González, 2010). Students accepted in IES present low performance due to several factors among which are the massification of the number of students attended per official group, which causes many of the activities of education to lower in quality, such as personalized attention, academic advising and homework review; mainly the evaluation activity, is one of the most affected since the work involved, is multiplied by increasing the number of students, causing a high failure rate (Aguirre-Jones, 2020). "The problem of low student achievement tends to worsen as students are arriving worse prepared than in previous years" (Posso-Agudelo, 2005).

In the training of the Engineer, Mathematics is of utmost importance, because it promotes the development of skills that allow posing and solving practical and theoretical problems inherent to the professional work; this is achieved through the formulation, solution and interpretation of models that represent the behavior of systems in the face of the phenomena of nature (Muñoz-Amariles & Alvarez-Gonzalez, 2015). Therefore, it is justified that employers give the lowest valuation to the analytical and logical capacity of young people to their ability to solve problems, to work autonomously and exercise leadership at work (Martinez-Sánchez & Lara-Gomez, 2019).

Because of this situation, HEIs have developed different strategies to solve this academic trend: such as propaedeutic, virtual or tutoring programs (Díaz-Perera, Luna-Flores, & Salinas-Padilla, 2019).

Propaedeutic courses are one of the tools used by higher level educational institutions that allow leveling incoming students, allowing them to adapt more easily from one level to another (Cosgalla-Barrera, Castro-Villagrán, & Diaz-Rosado, 2019).

Currently, it is important the acquisition of knowledge through the innovation of educational technology, implementing modern methodologies of education, to allow achieving different strategies, techniques and educational processes facilitating learning in the construction of knowledge (Ruiz-Reynoso, Delgadillo-Gómez, Hernández-Bonilla, & Cotera-Regalado, 2018).

There are several online learning platforms, however, one of the most recognized worldwide is the well-known Khan Academy, which has short classes in the form of videos and includes exams and exercises to complement them. The success and recognition it achieves is due to the constancy and frequency of use by the student, which is self-administered at their own pace (Lara-Pinales, Neira-Rosales, & Cedillo-Salazar, 2020). Some studies demonstrated the direct relationship between the use of information technologies and increased academic performance in higher education students, one can also mention the possibility of a relationship between the use of information and communication technologies, self-regulated learning and academic performance (Onivehu, Adegunju, Ohawuiro, & Oyeniran, 2018).

In the Faculty of Engineering of the Autonomous University of Campeche since 2018 the virtual propaedeutic course has been applied, through the online learning platform Khan Academy for incoming students, of the six Bachelor's Degrees in Engineering, due among many reasons for the impossibility of carrying out a face-to-face propaedeutic course or the implementation of a zero semester mainly due to administrative and legal aspects of the University (Canto-Canul, López-Martínez, Salazar-Uitz, & Lezama-Zarraga, 2020).

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Methodology to be developed

Starting in 2018 and year after year, the propaedeutic course has been taught online on the Khan Academy platform to incoming students of the Faculty of Engineering of the Autonomous University of Campeche. The structure of the propaedeutic course is made up of four main topics:

1. Pre-algebra.
2. Fundamentals of algebra.
3. Algebra 2.
4. Trigonometry.

Of which the activities are distributed by the type of educational resource and by the subject to which it belongs Table 1, 2 and 3

School Cycle 2018-2019 2019-2020	**Pre-algebra**	Fundamentals of algebra	Algebra 2	Trigonometry
Videos	13	35	19	9
Exercises	16	27	15	7
Questionnaires	3	5	5	0
Unit Testing	0	3	0	1
Articles	6	6	7	5
Subtotals	38	76	46	22
Total				182

Table 1 Structure of the Propaedeutic Course of the 2018-2019 and 2019-2020 school cycle
Source: Own Elaboration

Table 1 shows the activities of the propaedeutic course implemented in the 2018-2019 and 2019-2020 school cycles, including video exercises, questionnaires, unit tests and articles totaling 182 activities.

Table 2 shows the activities of the propaedeutic course taught in the 2020-2021 school year, different from the activities of the two previous years, because some activities have been removed from the platform or the contents were updated, so new activities were selected congruent with the needs of the course, with a total of 168 activities.

School Cycle 2020-2021	**Pre-algebra**	Fundamentals of algebra	Algebra 2	Trigonometry
Videos	12	32	14	9
Exercises	16	28	13	7
Questionnaires	3	4	2	0
Unit Testing	0	3	0	1
Articles	6	6	7	5
Subtotals	37	73	36	22
Total				168

Table 2 Structure of the Propaedeutic Course of the 2020-2021 school cycle
Source: Own Elaboration

Table 3 shows the activities of the propaedeutic course in the 2021-2022 cycle, including video exercises, questionnaires, unit tests and articles for a total of 189 activities, again the contents were updated, but always complying with the initial needs.

School Cycle 2021-2022	**Pre-algebra**	Fundamentals of algebra	Algebra 2	Trigonometry
Videos	13	40	19	8
Exercises	16	29	15	7
Questionnaires	3	5	3	0
Unit Testing	0	3	0	1
Articles	6	8	7	6
Subtotals	38	85	44	22
Total				189

Table 3 Structure of the Propaedeutic Course of the 2020-2021 school cycle
Source: Own Elaboration

The application of a diagnostic test together with a survey before starting the propaedeutic course is relevant because it allowed measuring the level of knowledge of incoming students. The test consisted of 10 problems of medium difficulty and also included six questions as a survey to gather information on the preferences they have regarding study in this modality:

1. What method do you prefer to study?
2. Have you used any of these digital teaching methods?
3. Do you consider that the digital teaching methods have displaced the conventional methods?

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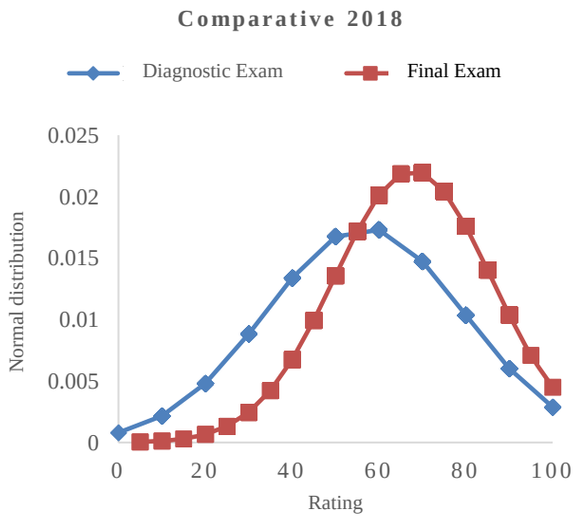
4. How do you prefer to take a propaedeutic course?
5. What do you consider to be the main disadvantage of distance learning?
6. What do you consider to be the main disadvantage of studying face-to-face?

After the propaedeutic course to measure the level of knowledge acquired with respect to the diagnostic exam, a final exam was administered with the same difficulty; an exit survey was also included in which opinions were collected regarding the experience and degree of satisfaction with the course in this modality. The two exams were administered by means of Google Forms.

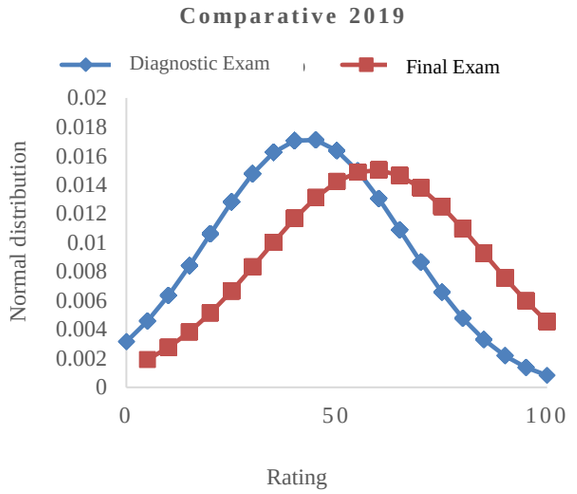
Results

The results were obtained in a period of four years in which the propaedeutic course was applied in the virtual modality.



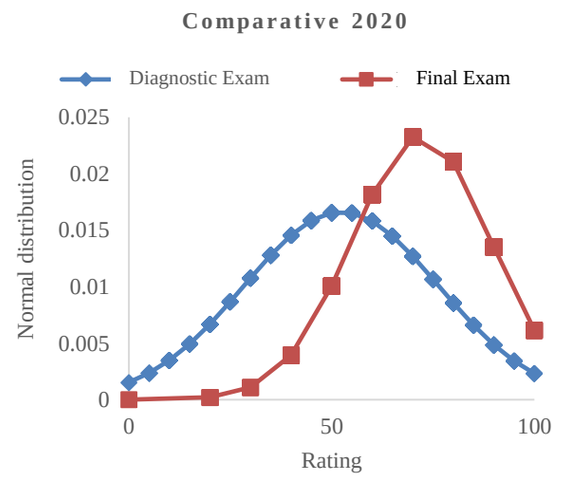
Graph 1 Comparative normal distribution of the 2018 diagnostic and final exam
Source: Own Elaboration

Graph 1 shows the normal distribution of the diagnostic and final exam results, proving that for year 2018 the propaedeutic course caused a positive impact on incoming students, reflected in displacement, with respect to the mean of diagnostic exam grades, of the mean of final exam grades, from 56.7 to 67.8 with an improvement of 11.1 grade points: the curve of the final exam is higher than the curve of the diagnostic exam which indicates that a greater number of students improved their grades.



Graph 2 Comparative normal distribution of the 2019 diagnostic and final exam
Source: Own Elaboration

Graph 2 shows the normal distribution of the results of the diagnostic and final exam, proving that for the year 2019 the propaedeutic course caused a positive impact on the incoming students, reflected in the displacement, with respect to the mean of the diagnostic exam grades, of the mean of the final exam grades, from 42.8 to 58. 9 with an improvement of 16.1 grade points: in this case the curve of the final exams was lower than the curve of the diagnostic exam, however, it is possible to observe a decrease in the number of students who obtained a grade below the average and an increase in the number of students who obtained a grade above the average.



Graph 3 Comparative normal distribution of the 2020 diagnostic and final exams
Source: Own Elaboration

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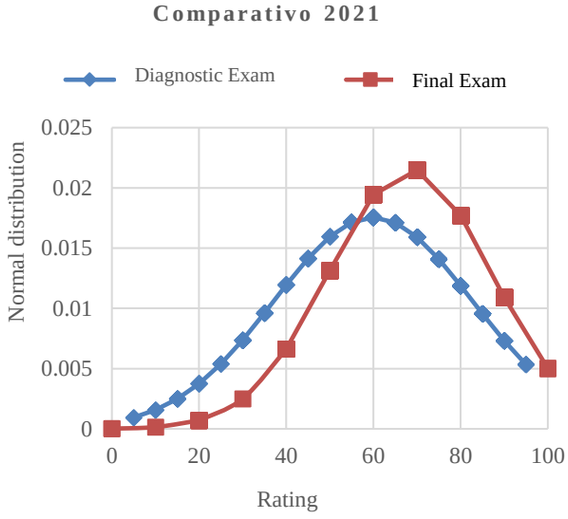
Graph 3 shows the normal distribution of the results of the diagnostic and final exam, proving that for 2020 the propaedeutic course had a positive impact on the new students, reflected in the displacement, with respect to the mean of the diagnostic exam grades, of the mean of the final exam grades, from 52.4 to 72.1 with an improvement of 19.7 grade points: the curve of the final exam is higher than the curve of the diagnostic exam, which indicates that a greater number of students improved their grades.



Graph 4 Comparative normal distribution of the 2021 diagnostic and final exams
Source: Own Elaboration

Graph 4 shows the normal distribution of the results of the diagnostic and final exam, proving that for 2021 the propaedeutic course had a positive impact on the new students, reflected in the displacement, with respect to the mean of the diagnostic exam grades, of the mean of the final exam grades, from 59.9 to 68.4 with an improvement of 8.5 grade points: the curve of the final exam is higher than the curve of the diagnostic exam, which indicates that a greater number of students improved their grades.

Diagnostic Examination	Cycle 2018-2019	Cycle 2019-2020	Cycle 2020-2021	Cycle 2021-2022
Media	56.7	42.8	52.4	59.9
Standard deviation	22.8	23.2	24.0	22.7
Median	60.0	40.0	55.0	65.0

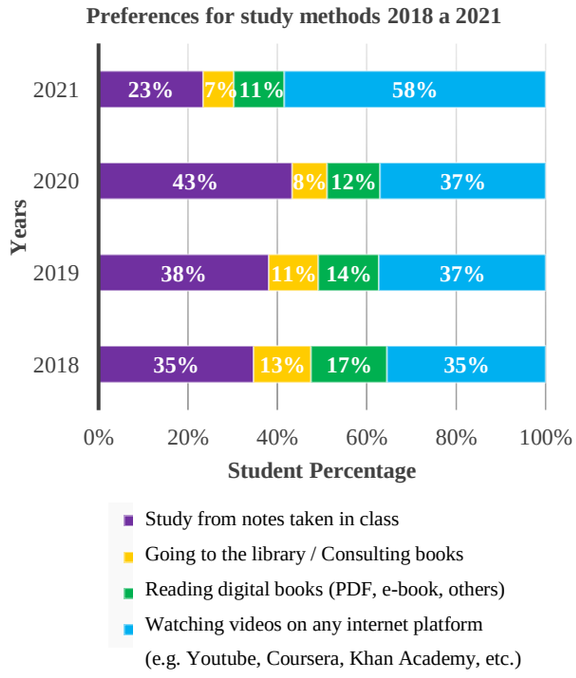
Table 4 Table of mean, standard deviation and median of the scores obtained in the diagnostic exam for the last 4 school years.
Source: Own elaboration

Table 4 shows that in the 2018-2019 cycle the mean was higher than the two subsequent years, in the 2021-2022 cycle the mean was above the mean of the previous years. For the 2020-2021 cycle the standard deviation is higher than the other school cycles indicating a greater dispersion of data with respect to the mean.

Examen Final	Cycle 2018-2019	Cycle 2019-2020	Cycle 2020-2021	Cycle 2021-2022
Media	67.8	58.9	72.1	68.4
Standard deviation	18.0	26.5	17.0	18.5
Median	75.0	60.0	80.0	70.0

Table 5 Table of mean, standard deviation and median of the grades obtained in the final exam for the last 4 school cycles
Source: Own Elaboration

In Table 5 it is noticeable that in the 2020-2021 school year the improvement in terms of the mean moved above the passing grade and the dispersion with respect to the mean is lower, therefore, it indicates a significant progress compared to the other school years. In general, the statistical parameters in Table 5 (final exam) show an improvement in their grades with respect to the statistical parameters in Table 4 (diagnostic exam).



Graph 5 Preferences for study methods in the last four school years
Source: Own Elaboration

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Graph 5 presents the preferences of the study methods of the incoming students in the four school cycles studied, this graph is the result of the survey of the diagnostic test of the question:

1.- What method do you prefer to study?
a) Study from notes taken in class.
b) Going to the library / consulting books.
c) Reading digital books (PDF, e-book, others).
d) Watching videos on any internet platform (e.g. YouTube, Coursera, Khan Academy, etc.).

From the 2018-2019, 2019-2020 and 2020-2021 school cycle, the percentages of preference remained similar, except in the 2021-2022 cycle where the trend leans towards Watching videos on some internet platform (for example: YouTube) with a 58% preference.

Acknowledgment

We would like to thank the Universidad Autónoma de Campeche and the Faculty of Engineering for the facilities and support granted to develop and implement this research project.

Conclusions

There is a trend that had been occurring, in which it states that the problem of low student achievement tends to worsen since students are arriving worse prepared than in previous years (Posso-Agudelo, 2005); this can be observed in Table 4 where the 2018-2019 and 2019-2020 cycles is evidenced by comparing the averages of the results of the diagnostic exam, which does not apply with the following 2020-2021 cycle, but if it is repeated between the 2018-2019 and 2020-2021 cycle, in the last school cycle there is a higher average score than the previous ones and the trend is no longer present. In the cases studied, none of them presents an average passing grade, so it seems critical that the immediate previous educational level is not causing significant learning in their graduates and makes it necessary to develop strategies for their regularization.

Graphs 1, 2, 3 and 4 demonstrate the relationship between the use of information and communication technologies (Lagunes-Paredes, Ramirez-Roman, Suarez-Alvarez, & Valazquez-Camilo, 2018), self-regulated learning and academic performance.

With a positive impact, increasing from 8.5 points to 19.7 points out of 100 points in the school cycles studied. Therefore, the virtual propaedeutic course is giving the expected results, however, the average of the grades obtained is worrying, because in the cases studied only one cycle is above the passing grade. Thus, efforts should be focused on moving the average grade as high as possible, improving this strategy or complementing it with other tools to improve school performance.

It is interesting to see the results of the survey on the preference for study methods, which has a percentage in the 2021-2022 cycle of 58% for the option of watching videos on some internet platform, in contrast to the school performance shown in Table 5, which shows that the average went down again, after the previous cycle it went up above the passing grade. In this case it is necessary to study what other factors influenced both in the 2020-2021 cycle compared to the 2021-2022 cycle and if there is any relationship.

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The effectiveness of a course taught in the flipped classroom modality

La efectividad de un curso impartido en la modalidad de aula invertida

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Abstract

The purpose of this research was to determine, through the Kirkpatrick and Kirkpatrick evaluation model, the effectiveness of a course taught in the flipped classroom modality to students of Information Technology Engineering at a Technological University in Mexico. This model comprises four levels for measuring the effectiveness of a training program: satisfaction, learning, applicability and results. To carry out the present study, a methodology with a quantitative approach and a quasi-experimental design of a group with measurement before and after, without a control group, was used. To measure the level of learning, the group was evaluated by a pre test starting the course and by a post test after finishing it. To measure the levels of satisfaction, applicability and results, Likert-type questionnaires were administered. The results showed that the level of satisfaction of the course participants was 86.6%. Regarding the level of learning, it was found that students improved their learning by 25.3%. Regarding the applicability, 86.5% was obtained, while 89.2% was reached for the level of results. In conclusion, it was possible to conclude that the course taught in the flipped classroom modality was effective.

Effectiveness, Flipped classroom, Kirkpatrick's model

Resumen

El propósito de esta investigación fue determinar, mediante el modelo de evaluación de Kirkpatrick y Kirkpatrick, la efectividad de un curso impartido en la modalidad de aula invertida a alumnos de la Ingeniería en Tecnologías de la Información de una universidad tecnológica de México. Dicho modelo comprende cuatro niveles para la medición de la efectividad de un programa de formación: satisfacción, aprendizaje, aplicabilidad y resultados. Para realizar el presente estudio se empleó una metodología con enfoque cuantitativo y un diseño cuasi-experimental de un grupo con medición antes y después, sin grupo de control. Para medir el nivel de aprendizaje, el grupo fue evaluado mediante una prueba antes de iniciar el curso y después de finalizarlo. Para medir los niveles de satisfacción, aplicabilidad y resultados se administraron cuestionarios tipo Likert. Los resultados demostraron que el nivel de satisfacción de los participantes del curso fue del 86.6%. Respecto al nivel de aprendizaje, se comprobó que los estudiantes mejoraron su aprendizaje en un 25.3%. En cuanto a la aplicabilidad, se obtuvo un 86.5%, mientras que se alcanzó un 89.2% para el nivel de resultados. Como conclusión, se pudo concluir que el curso impartido en la modalidad de aula invertida fue efectivo.

Efectividad, Aula invertida, Modelo de Kirkpatrick

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Introduction

With the advent of Information Technologies in the classroom, several new teaching methodologies have emerged in higher education, which are, according to Aznar and Romero (2018), e-learning, blended learning, flipped classroom and mobile learning. All of them are characterized by the active role of the student and self-regulated learning (Chaves, Trujillo & López, 2016). If nowadays, both students and teachers are immersed in a society in which the applications of technological development impact the way in which teaching and learning take place, it is necessary to take advantage of this trend and raise the need to change traditional teaching methodologies for a new approach called flipped classroom (Reyes, Dzul & Melken, 2019).

The research problem

In this sense, in a technological university in Mexico, located in Nuevo Vallarta, Nayarit, the professional career of Information Technology Engineering is offered. Recently, in 2018, the curriculum of that academic program was updated, thus replacing Plan 2009 (A. Ochoa, personal communication, 2018). With this update, the number of hours of the Database course, which is taught in the second quarter, was reduced from 6 to 4 hours per week. This is equivalent to a reduction from 90 to 60 hours per four-month period, considering that the four-month period has a duration of 15 weeks (CGUTyP, 2009, 2018).

It is relevant to take into account that, although there is a reduction of 30 hours per quarter, the 2018 curriculum generally retains the same thematic content, although reorganized with respect to the 2009 curriculum. In fact, the learning objective of the Database course in the 2018 curriculum is literally the same as the corresponding one in the 2009 curriculum. It should be noted that, in the case of this technological university in Mexico, the study plans and programs are dictated by the General Coordination of Technological and Polytechnic Universities, through the Subdirection of Educational Programs (CGUTyP, n.d.).

For the professors who are members of the Information Technology Academy, the reduction in the number of hours in the Data Base course is considerable and casts doubt on the students' achievement of the learning objectives. According to this collegiate body, the programmatic progress, from the outset, is affected by holidays, and sometimes by extraordinary situations such as bad weather, official events, teacher's commissions, among others (Academy of Information Technologies, 2019a).

To issue its deliberation, the academy took into consideration the final report of the course taught (Avila, 2019a), which was sent to the Academic Program Direction by the professor who taught the course Database in the January-April 2019 term. In said report, the academic refers to the time limitations faced by the course to achieve the objective indicated in the program. Another of the elements analyzed by the collegiate body was the teaching evaluation answered by the students who took the referred course during the January-April 2019 term. In the results of this evaluation, the students expressed several comments that revolve around the fact that they felt that the weekly time dedicated to the subject was not enough and that they would have preferred to have more hours of this class (Academy of Information Technologies, 2019b).

In this regard, the IT Academy has determined that there is a need to compensate for the number of hours that were reduced. Once the issue was discussed by the members of the collegiate body, the conclusion was reached to use the inverted classroom model in the delivery of the Database course and that it is necessary to evaluate its effectiveness in order to validate the initiative and eventually propose to the university administration its extension to other subjects of the same program or even to that of other educational programs.

Background and justification

According to Avila (2019b), in 2010, some professors of the Technological University of Mexico, obtained unsuccessful results when trying to teach online two subjects of Information Technology Engineering.

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As a subsequent initiative to assess the conditions to offer online courses, in 2012, a study was conducted that showed that there was a favorable context for students to start studying some courses in the virtual modality (García, et al., 2012). Based on what was indicated by the study conducted in 2012, in the following years 2013, 2014 and 2015 some subjects of the professional career of Information Technology Engineering were taught using a mixed model, i.e., mixing face-to-face and virtual activities. During that time, no formal or systematic evaluation of the results of this initiative was carried out.

It was until 2019, when Avila (2019b) conducted a scientific research work to evaluate the effectiveness of a Database course taught in the blended learning modality in Information Technology Engineering. The study was based on Kirkpatrick and Kirkpatrick's (2009) evaluation model and the conclusion obtained indicated that the blended learning course was effective. Although Avila's (2019b) research is a serious and rigorous study that proves the effectiveness of the blended learning modality, it is necessary to corroborate whether the inverted classroom model is also effective. This is because, although both approaches have similarities, they have a marked difference in that in the inverted classroom the explanations of the contents are addressed strictly outside the classroom and the implementation is done inside the classroom, a condition that does not necessarily occur in the blended learning model.

To address the above need and also with the aim of complementing the number of teaching hours of some subjects, the Academy of Information Technologies, through its president (H. Gerardo, personal communication, July 08, 2019) has expressed the urgency of knowing the effectiveness of a blended learning course attached to the characteristics of an inverted classroom. This concern becomes more relevant when knowing that one of the work prospects that resulted from the systematic review of the literature conducted by Hinojo, Aznar, Romero and Marín (2019) is to continue investigating the effect of the inverted classroom on the learning of students at the higher education level, since, according to the same authors, this approach is being placed as an educational trend.

Making a comparison of the syllabus of the Database subject plan 2018 versus plan 2009, with respect to the number of total hours of the course, it can be noticed that there is a deficit of 30 hours, going from 90 to 60 hours per four-month period. However, the learning objective remains the same "the student will perform the design, creation and manipulation of relational databases through the requirements established for information management".

Referring to the above, in one of the meetings held by the Academy of Information Technologies, the professors of said collegiate body discussed the risk of the student not reaching the level of competence in Databases due to the drastic reduction in the number of teaching hours of the course. The Academy minutes were recorded a point of agreement urging the use of the inverted classroom model to compensate the study time of the thematic contents of the subject Database (Academy of Information Technologies, 2019a).

Definition of Terms

Inverted classroom. It is an academic strategy, based on learning with online videos and tutorials, commonly viewed outside the classroom; what was previously referred to as an assignment to work at home, is performed during class time, while the explanation is provided outside the classroom (Santiago & Bergmann, 2018).

Effectiveness. It is the impact of learning evaluated through objectives that serve as a reference to make comparisons in obtaining concrete results (Armenta, 2019).

Satisfaction. It is the attitude presented by students regarding the course (Kirkpatrick & Kirkpatrick, 2009).

Learning. It is defined as the point at which students show a transformation through the expansion of their knowledge, their skills, which is the result of the formative action that the teacher provides in each of the sessions.

Application. It refers to the usefulness that a course has on the participant, seen as a transfer of knowledge (Kirkpatrick & Kirkpatrick, 2009).

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Outcomes. It is the impact due to the behavior demonstrated by the student participant. It can also be defined in relation to the final results shown by the learners when the course culminates (Kirkpatrick & Kirkpatrick, 2009).

Purpose of the Study

The purpose of this research work is to determine, through Kirkpatrick and Kirkpatrick's evaluation model, the effectiveness of a course taught in the inverted classroom modality to students of the Information Technology Engineering educational program, specifically in the subject of databases, at a technological university in Mexico.

Literature review

In modern times, there is a range of possibilities for teaching a class (Velazco, Bojórquez and Armenta, 2009). The use of innovative strategies as a learning strategy can generate positive results in the short and medium term in a classroom.

The need that exists in higher education institutions (HEIs) to improve educational practices is closely related to innovation (Ríos, 2009), and in the Mexican educational context, the teaching-learning scheme has been based solely on the transmission of knowledge (Romo, 2011).

The fact of teaching a different and innovative class in the classroom allows student learning and the integral development of the teacher. According to data from ANUIES (2002), renewing and changing the pace of teaching helps to enhance the skills, competencies, abilities and above all the student's interest in the classroom.

In order to provide better educational practices in Mexican universities, a work methodology is introduced. In 2006, the concept of inverted learning appeared (Bergmann and Sams, 2017). Since then it has gone through several stages of development, however, the original concept was always the inverted classroom. In this approach, the teacher was at the center of instruction.

Later the concept changed to inverted domain model, but still focused on the teacher, and the transfer of knowledge. The advantage it had after several applications, is that it managed to consider the learning pace of the students, and the didactic contents were adapted to the needs of the students (Bergmann and Sams, 2017).

Some time later, when the concept was modified to inverted learning, the student was already the center of the classroom and, therefore, the instructional and learning strategies were already implemented with a specific objective: to generate deep and lasting knowledge in the learner (Sams and Bergmann, 2013). These authors suggest that the teacher should not be the center of instruction, and that idea changed the learning processes that are learner-centered. Under these premises, teachers are the providers of meaningful and quality learning.

Learning problems have been studied for decades, and according to Martínez and Nortes (2014), Sánchez, Segovia and Miñán (2011), the triggering factors of these problems are derived from anxiety and mostly towards the attitude of the classes. This causes low performance in students and, therefore, failure. Faced with this situation, the need to implement changes in the traditional ways of giving a lecture is born. Under the traditional schemes in which we have worked, it is required to innovate with methodologies that drive the student to meaningful learning, and as a consequence, a higher rate of academic performance (Moya and Williams, 2016). In the same way, Parr and Fung (2000), agree that academic performance can be increased as technology is used and, above all, in the pedagogical techniques appropriate for the group.

Moya and Williams (2016), make a proposal for innovation, which was considered an educational model, assisted by technology, which is currently called flipped classroom, or as in English it is called flipped classroom. The idea of this flipped classroom model has its origin in the delivery of digital content at a distance, either by a platform, page, email or similar, highlighting the collaborative work in the classroom.

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Flipped classroom

The origin of an inverted classroom began with the initiative of Bergman and Sams (2012), chemistry teachers, who consolidated the term flipped classroom, and it is known as inverted classroom. They proceeded with this method, trying to achieve a general objective, which was to keep students, who for various reasons were absent from class, to take the same orientation as those who could attend, and none were affected by lack of knowledge and/or absence. To achieve this result, they decided to document the contents of the subjects with software that allowed them to record the presentations and narrations in power point to share with the students.

Over time, they realized that the material was not only used by students who could not attend the sessions, but the students who did attend, used them as a tool to review the lessons (Berenguer, 2016). Thus, they began to reverse their teaching methodology, sharing videos of the sessions for students to review them at home before class, and using class hours to generate and solve projects where the knowledge acquired with the videos was evidenced, in addition to resolving doubts in case they existed.

According to Bergmann, Sams, Daniels, Bennett, Marshall and Arfstrom (2014), who are the main leaders of flipped learning in the classroom, consider it as a pedagogical approach, where learning begins collectively and concludes in individual learning, where the path is characterized by being dynamic and interactive when applying the contents learned and when working in class hours. For their part, Santiago, and Bergmann (2018) point out that it is an academic strategy, based on learning with online videos and tutorials, commonly watched at home; what was previously referred to as a homework or assignment to work at home, is done in class time, while the explanation is provided outside the classroom.

It is of vital importance to highlight the importance of this teaching model, since the student learns to work in an autonomous way, however, he/she does not do it alone, since he/she is accompanied by the teacher.

What is different from traditional learning methodologies are the roles played by each of the authors, since the student actively participates in his own learning (Berenguer, 2016).

Four pillars of the flipped classroom

Bergmann et al. (2014), state that, frequently, teachers refer to the inverted classroom as working at school at home, and the work at home at school, which is also correct, but inverted learning is a perspective where the teacher can apply different methodologies in the classroom, according to the context and characteristics of the students. To achieve favorable results, the aforementioned authors propose four pillars of the inverted classroom for its appropriate practice:

Flexible environment. When implementing flipped learning, it implies the inclusion of a range of learning procedures and strategies. Likewise, the teacher adapts the learning space according to the competencies, learning and skills he/she wants the student to acquire, in order to promote collaborative and individual work.

Learning culture. In the original teaching and learning models, the focus was on the teacher (Ferreiro, 2010). Now, with this type of instruction, the focus is on the student and his or her needs, and the time spent in the classroom is used to generate experiences to achieve meaningful learning.

Content directed. The teacher constantly seeks strategies to strengthen the students' knowledge and support the development of conceptual understanding and ease in the learning process. The teacher makes a selection of what the student needs to learn and explore on their own, and it is the teacher who directs the content, time and materials in order to optimize the academic resources at their disposal and achieve their goal.

Professional facilitator. The professional role of the teacher working with the inverted class methodology demands more time for the elaboration of the material to be distributed, as well as the planning and execution of activities that the student will carry out in the class sessions, in addition to the continuous and close follow-up provided to the student.

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Although it may be perceived that a professional facilitator plays a less prominent role in a flipped classroom, they are the fundamental component to give rise to flipped learning.

For his part, Calvillo (2018), proposes a table containing the description of each of the pillars, in addition to a series of indicators associated with each pillar, where specific activities that the teacher, who implements the inverted classroom methodology, commits to execute are detailed. From the four pillars, 11 indicators emerge, which can also be used as compliance indicators.

Flipped Class Methodology

The way in which the flipped classroom is carried out, unlike the traditional methodology, is that the time dedicated by the teacher to develop the topics and contents of the class program, is left to the judgment of the student, who applies a constructivist vision on the flipped classroom (Serrano and Pons, 2011), which will be converted into knowledge, built by the student, owners of their learning process.

This methodology was proposed as a strategy to improve the stimuli to the student, with the main objective of strengthening the competence of student autonomy. According to Moya and Williams (2016), it also contributes to the development of: (a) organizational skills; (b) planning skills; (c) communication skills; (d) decision-making skills.

With the inverted classroom methodology, the student becomes the protagonist of his or her own learning, which is reflected in his or her academic performance. This is presented as a contribution focused on educational quality in higher education (Madrid, Angulo, Prieto, Fernández, & Olivares, 2018). To this end, Moraros, Islam, Yu, Banow, Schindelka, (2015), Angelini, García (2015) and González, Jeong, Airado, and Cañada (2016) agree on a series of steps, which they call a 10-step methodology for a flipped classroom:

1. Programming. At the beginning, the learning objectives should be defined and outlined, as well as the competencies that students should develop with the didactic content. Moraros et al. (2015) recommend a broad search for resources that can be attractive to students from the moment they discover them, as this will motivate them to learn. An organized planning of each of the sessions is recommended, allocating the corresponding assignments before, during and after the sessions.

2. Preparation of material. It is vitally important to prepare the materials that will be used for the explanation and, above all, the understanding of the topics. Gonzáles et al. (2016) recommend that the material can be own and unpublished content, although it could also be a video collection, presentations, informative clips, learning objects, and other digital tools for the student to make the knowledge his own. It is also important to include an evaluation that validates the knowledge acquired by the student.

3. Review of the material at home. The didactic material elaborated or selected should be sent to the students, so that they can learn and review the subject at home. They should be asked to complete the questionnaires or reading control mechanisms and/or activity to share and express when they have doubts.

4. Plan class sessions. The sessions should be planned with materials and/or exercises elaborated according to the doubts expressed by the students. Angelini and García (2015) indicate that activities should be developed and selected individually or in groups, in order to meet the heterogeneity of the class. In addition to including collaborative activities to strengthen active and collaborative learning in the student (Ferreiro, 2010).

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5. Solution of doubts. To work with this methodology, it is important to dedicate the first minutes of class to review the work control instruments such as questionnaires and/or essays and/or exercises, in order to clarify doubts about the topics. The promotion and encouragement of student participation in the classroom should be considered.

6. Strengthening of the activities. The knowledge acquired in the previously designated activities should be strengthened. The areas of opportunity of each student can also be detected and work with them according to their specific needs.

7. Collaborative work. According to Ferreiro (2010), to promote collaborative work, not only one session is not enough, but two to four sessions should be dedicated, since the student will be challenged to solve problems, develop projects, generate their learning through experiments, participate in debates, and it is the teacher who must guide them to the realization and mastery of each of these skills.

8. Study away from home. The teacher should encourage students to work in teams, beyond the classroom, generating collaborative work spaces with their classmates. It is also the teacher's role to provide guidance and supervision to avoid doubts that may cause the work to be truncated.

9. Verification and study. The work done by the student should be reviewed and shared with the entire class. They should be encouraged to express their perception of the work methodology, as well as their learning experience, to culminate resolving any doubts that may remain.

10. Evaluation and self-evaluation. The evaluation of the student should be through a rubric that contains the objectives and competencies to be acquired and that were proposed at the beginning of the class and/or topic. The evaluation can also be a self-evaluation, where they themselves issue a value judgment to the work they did, and in turn, exercise the co-evaluation with their peers. This will encourage them to develop critical and reflective thinking about their successes and areas of opportunity.

Designing a course

Each Higher Education Institution generates its learning programs and courses (ANUIES, 2012). For this, according to Romo (2011), interaction and flexibility are required, since the design of a course program and its respective class plan are two essential components to achieve success in the learning environment under any modality, whether face-to-face, blended or online.

When these components of interaction and flexibility are present, it can support the decrease, or even the elimination of procrastination in students, as well as other aspects related to this variable (Dominguez, Villegas and Centeno, 2014). Likewise, Ríos (2009), mentions that there should be a strong focus on the design of online courses, including daily and weekly structured assignments.

On the other hand, according to the indications of ANUIES (2012), interaction should encourage students and faculty to maintain a close relationship with respect to course materials and content. Likewise, flexibility should be encouraged within the activities and in the formation of work teams. In these cases, the use of the flipped classroom as a parallel strategy to face-to-face sessions generates positive effects on meaningful learning and understanding of academic content (Moya and Williams, 2016).

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When designing an online course, or implementing activities such as the flipped classroom strategy, one is fostering student success, as one of the pillars in the improvement of existing education is being addressed (Cherif et al., 2019). Boiling, Hough, Krinsky, Saleem and Stevens (2012), question about the existing forms of online courses, as in some cases the expected result is not being obtained, and argue that new alternatives must be found.

Returning to the ideas of Ros and Rosa (2014), there are principles for an effective practice and design of blended courses, which will definitely contribute to the success of students in higher education. These are: (a) the promotion of contact between students and teachers; (b) the development of reciprocity and cooperation among students; (c) the stimulation of active learning; (d) the emphasis on the time of completion of activities; (e) clearly explaining the expectations of the course; and (f) respect for the diversity of student learning.

Evaluation Models Referent to the Transfer of University Education

Once the variables that are considered effective for virtual didactic content (Ocampo et al., 2014), it is important to review the approaches derived from formative plans, commonly called evaluation and development models. From the first point of view is that of Aramburuzabala (2013), who indicates that each educational institution indicates the formative approach and practice, since they generate their student training model according to their objectives, vision and mission.

On the other hand, Villar (1992), emphasizes the professional development models, which consider the knowledge, skills, abilities and above all the attitude of the teacher, which will be decisive in the development of the student during their professional training. It also proposes four types of treatment that the university professor can apply in the classroom:

1. Individual improvement, to locate and attend to the needs of all those involved in the educational act.
2. Evaluation for the improvement of teaching, for the feedback to the teacher himself, and to the student in his training process.
3. Inquiry, for reflection on educational practice.
4. Organization, in order to establish a specific training determined by the university.

In another sense, effectiveness is a topic that generates controversy in learning (Armenta, Zea, Abundis, & Quiroz, 2019), since the effectiveness and impact of learning can be closely related, because when effectiveness is evaluated, the objectives, established in the educational context, will serve as a starting point in making comparisons in obtaining concrete results (Armenta, 2019). When conducting evaluations of effectiveness and the desired impact on students, there is no perfect or optimal model in a consensual manner.

To date, one of the best known and most widely used models is Kirkpatrik (2007), in which he considers a series of study levels, which are: reaction, learning, behavior and, finally, results. The research application of these levels is as follows:

1. Reaction. This factor assesses the confrontation of students in their academic training, which is very similar to the evaluation of the satisfaction of a customer in a company, however, it is expected that students present a favorable attitude, since effective learning will depend on it, otherwise, there is no reason to justify learning.

2. Learning, which is defined as the point at which students show a transformation through the expansion of their knowledge, their skills, which is the result of the formative action that the teacher provides in each of the sessions.

With this type of evaluations, the acquisition of knowledge can be assessed in the classroom or virtually, with the use of virtual platforms, or computer content used for academic purposes. Also, what is expected to be evaluated are mainly three aspects, which are knowledge, skills and attitudes.

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These three components will be decisive in their professional performance when facing situations that must be solved.

3. Behavior. This is seen as a transfer of knowledge, and can be determined through the change that the student demonstrates inside and outside the classroom, being a consequence of class attendance and their academic and professional training. Through behavior, an analysis is made of the information and usefulness of the course, subject and/or session for the participant.

4. Results. The result can sometimes be seen as an impact, due to the behavior demonstrated by the student participant. It can also be defined in relation to the final results shown by the students when the course ends. Within this, what is considered is the production generated, the contribution to knowledge, the quality of the knowledge itself, and the frequency with which the student participates in the activities proposed by the teacher.

In order to carry out an evaluation that contains these elements, it is necessary to consider one more level, because according to Armenta, et. al (2019), the course design must be functional, that is, effective, efficient and, above all, relevant. The elements that will make up the course must also be considered, as well as the impact it will generate on the user, which in this case is the student participant.

Chalmers (2012), on the other hand, takes Kirkpatrick's model as a reference, the same that must be answered in the design and training phase. The sole purpose is to choose the most appropriate learning strategies to generate impact on knowledge acquisition.

Research Questions

1. What is the level of satisfaction of the students with respect to the database course studied in the inverted classroom modality within the educational program of Engineering in Information Technologies of a technological university in Mexico?

2. What is the level of learning obtained by the students who studied the database course taught in the inverted classroom modality within the educational program of Engineering in Information Technologies of a technological university in Mexico?

3. What is the applicability of the knowledge and skills acquired by the students who studied the database course taught in the inverted classroom modality within the educational program of Information Technology Engineering of a technological university in Mexico?

4. What are the results obtained in the end-of-semester project by the students who studied the database course in the inverted classroom modality within the Information Technology Engineering educational program of a technological university in Mexico?

Methodology

The selected sample that was the object of this study consisted of eighteen students, who are regular students enrolled in group 2 "A" of the Information Technology Engineering program. The sample was determined through a non-probabilistic method, which consists of not selecting the participants at random. This is due to the fact that the composition of the groups was dictated by the School Services Office and the assignment of group 2 "A" to the professor who taught the course in inverted classroom mode was a decision made independently by the director of the educational program. In this sense, the researcher did not intervene in the selection of the sample, since it was the result of decisions beyond the researcher's control.

Instruments

To measure the level of satisfaction of the students with respect to the database course studied in the inverted classroom modality within the Information Technology Engineering educational program of a technological university in Mexico, the Questionnaire to Measure Satisfaction was used, which was obtained with the consent of its author, Dr. Correa (2013).

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To determine the level of learning, a pre-test and post-test was administered that measured the knowledge and skills around the subject of Database before and after the experiment. This test consists of fifty items intended to measure the level of knowledge and skills acquired by the students in the Database course. This instrument was designed by Avila (2019), who granted permission for its use and application.

To measure the applicability of the knowledge and skills acquired, the Questionnaire to Measure the Applicability of Learning was applied, which is composed of seven pre-coded and closed questions, offering answers with an ordinal Likert scale. To determine the level of results obtained in the end-of-term project by the students who studied the database course in the inverted classroom modality, the Questionnaire to Measure Learning Results was used, which is made up of closed and pre-coded items, with Likert-type response options.

Procedure

The methodological approach of the present research was quantitative, which included a quasi-experimental study with a before and after measurement group, but without a control group. This design did not constitute in itself a pure experiment because the sample to be studied was an intact group of students previously constituted and does not come from chance. To develop this research it was necessary to carry out the following series of activities:

1. The researcher asked the director of the academic program for authorization to carry out the research in coordination with the head professor of the database course in inverted classroom modality.

2. Once the permission of the academic director was obtained, the purpose of the research and the techniques to be used to collect the data, as well as his role in this process, were explained to the professor of the course. It is important to mention that the professor was in charge of designing and teaching the course in the inverted classroom modality, leaving the researcher completely outside this activity.

3. Subsequently, the purpose of the research was explained to the students in the group and they will also be informed that they have been chosen as participants in the sample. The doubts raised by the students were resolved and finally they were asked to sign a written document expressing their consent to participate in the research.

4. At the beginning of the course, the pre-test was applied to the students, which consisted of answering the Test to Evaluate Learning on the digital platform of the course. The purpose of this test was to measure the notions about databases that the students had before attending the course.

5. The participating students attended the database course under the inverted classroom modality taught by the professor in charge of the course.

6. Before finishing the course, the students answered the post-test, which consisted of the same questions as the pre-test and which was also available electronically on the course's digital platform.

7. Then, the participating students answered the Questionnaire to Measure Satisfaction, which was available electronically through the OnlineEncuesta.com platform.

8. Once the students presented their end-of-course project, which consisted of the design and creation of a database for a point-of-sale system, they answered the Questionnaire to Measure the Applicability of Learning, which was available on the OnlineEncuesta.com platform.

9. Finally, the course instructor was asked to answer the Questionnaire to Measure Learning Outcomes once for each of the participating students. The instrument was accessible only electronically by accessing the OnlineEncuesta.com platform.

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Results

Regarding research question number one, what is the level of satisfaction of the students with respect to the database course studied in the inverted classroom modality within the Information Technology Engineering educational program of a technological university in Mexico, it was observed that the students possess a degree of satisfaction of 86.6% on average, which is considered an acceptable percentage to represent the conformity of the group of students with respect to the database course taught in the inverted classroom modality. At the same time, it can be observed that the mode was 90.8%, a superior measure that supports the idea that the students were satisfied with the course.

The aspect of the course with which the students were most satisfied was that the Canvas learning system was adequate to deliver the course online. However, the aspects with which the students were least satisfied were the time distribution and relevance of the proposed exercises, as well as the course in general. According to Kirpatrick and Kirkpatrick's (2010) model, a degree of satisfaction of 86.6% represents that the students reacted with a favorable attitude towards the database course taught in the inverted classroom modality and with the support of the Canvas technological platform. The above agrees with Bergmann and Sams (2012b) who state that one of the benefits of using the inverted classroom paradigm is that by distributing the class material through the various technological media, empathy and interest is generated in the contemporary student. In the same sense, there is a coincidence of the results with those reported by Ros and Rosa (2014), since their research reinforces the idea that the inverted classroom increases student motivation.

Regarding research question two, which asks what is the level of learning obtained by the students who studied the database course taught in the inverted classroom modality within the Information Technology Engineering educational program of a technological university in Mexico, the processing of the data obtained for the learning variable indicates that the group of students increased their level of knowledge and skills in databases from 38% to 63.3% of qualification in general.

This means an average improvement of 25.3%, which was statistically validated by means of the t student test to compare paired means starting from a significance level of 0.05. With this test it was ruled out that the difference between the grades obtained in the pre-test and post-test is a product of chance and it was confirmed that the learning obtained by the students in the database course is real and statistically proven.

The above finding is congruent with the results reported by Ros and Rosa (2014), who in their studies found that the inverted classroom method helps to improve student learning. It also coincides with what was reported by Moya and Williams (2016), who stated that the use of the flipped classroom as a parallel strategy to face-to-face sessions generates positive effects on meaningful learning and understanding of academic content.

Research question number three deals with what is the applicability of the knowledge and skills acquired by students who studied the database course taught in the inverted classroom modality within the educational program of Information Technology Engineering at a technological university in Mexico? In this regard, the participating students stated that they had achieved a level of application of what they had learned equal to 86.5%. In addition, it should be noted that half of the students rated the applicability of the course above the average of the group in general, with 82.9% being the most repeated rating (mode).

It can be noted that the aspect most highly valued by the students was that the knowledge and skills acquired had application in their school, academic and/or professional environment, with 64.3% of the students "Totally agreeing" and 35.7% "Agreeing" with this statement. On the other hand, the element that received the least recognition from the students was the contribution of the course to improve the performance of their activities as members of the final project team.

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Taking as a reference the effectiveness evaluation framework proposed by Kirpatrick and Kirkpatrick (2010), the result obtained of 86.5% regarding the level of applicability can be understood as a positive change in the student's behavior, demonstrated inside and outside the classroom as a consequence of the implementation of the competencies acquired during the database course taught under the inverted classroom modality. The above, keeps some coincidence with what was found by Moya and Williams (2016) in the sense that the inverted classroom model contributes to strengthen the competence of student autonomy in the development of organizational, communication, planning and decision making skills.

Regarding research question number four, which asks, what are the results obtained in the end-of-semester project by students who studied the database course in the inverted classroom modality within the Information Technology Engineering educational program of a technological university in Mexico, positive results were obtained, since the level of results obtained by the students was 89.2% in general. In Kirkpatrick and Kirkpatrick's (2010) model, a score like the one achieved makes it clear that the database course taught in the inverted classroom modality generated a high impact on students. The above is in line with the contributions of Cherif et al. (2019), in relation to the fact that when activities such as the inverted classroom strategy are implemented, student success is being fostered, since one of the pillars in the improvement of existing education is being attended to.

In the results, it can be seen that, although the most frequent valuation (mode) was 100%, a little more than half (57.14%) of the students obtained a result lower than the sample mean. This means that four students were recognized with the maximum score by the teacher, while eight students obtained lower scores, located below the group average. Only two participants scored above the mean, but below 100%.

Regarding the aspects considered in the evaluation of the level of results, it should be emphasized that the most highly valued aspect was that the competencies developed by the student had an application in their school, academic and/or professional environment.

This is due to the fact that 85.7% of the students answered "Totally agree" and the remaining 14.3% answered "Agree". However, the aspect in which the students obtained a lower consideration in terms of the achievement of results was the one related to the usefulness of the course given in the student's personal development.

It is interesting to note that the outcome level was the one that received the highest rating in comparison with the other levels that make up Kirkpatrick and Kirkpatrick's (2010) referential framework, a fact that contradicts the assumption held by the same authors who state that as the level increases, it is more difficult to achieve the goals of the training program. It is likely that this inconsistency is due to the difference in the criteria used at the time of evaluating each level, since it is worth remembering that the applicability level was assessed by each of the participating students, while that of the results level was estimated by the course instructor.

Conclusions

The present research work revealed interesting results that provide information of great value for the community that makes up the technological university of Mexico. In the first place, its most important contribution is the generation of scientific knowledge on the effectiveness of the inverted classroom as a methodology for teaching courses. The knowledge obtained will be used as a supply to the university's rectory to face the challenges of implementing changes in the traditional ways of teaching, since, according to Moya and Williams (2016), the inverted classroom constitutes an innovation proposal that drives the student to meaningful learning and, therefore, a higher rate of academic performance.

In addition, thanks to the present study it was possible that, within the professional career of Information Technology Engineering, a course was taught for the first time in the inverted classroom modality, during which, as Sams and Bergmann (2013) referred, the student was the center of the classroom and the instructional strategies aimed to generate in the learner a deep and lasting knowledge.

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From the teaching perspective, this research implied a series of challenges for the course's head teacher since, as Bergmann and Sams (2017) warned, the students' learning pace had to be considered and the didactic contents were adapted to the students' needs.

According to the results, the database course taught under the flipped classroom modality satisfactorily achieved each of the four stages of Kirkpatrick and Kirkpatrick's (2010) model, which are satisfaction, learning, applicability, and outcomes. In this sense, it was concluded that the database course taught under the flipped classroom modality was effective.

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Instrument to evaluate teaching performance in class management (IEDDCC)

Instrumento para evaluar el desempeño docente en la conducción de clase (IEDDCC)

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Abstract

The objective of this work was to expose and validate the psychometric properties of a suitable instrument to evaluate teaching performance in classroom management (IEDDCC); the study was considered instrumental and a purposive sample of 108 academic figures in basic education was used for data collection. The results of the measurement of the psychometric properties of the instrument indicated a Cronbach's alpha reliability of 0.964 and, in the construct validity carried out through the "total domain" correlation test, a value of Spearman's Rho coefficient of 0.978 was obtained, values considered to be quite acceptable. With respect to the confirmatory validity test carried out through the linear regression test, information was also obtained that supports these results; among them, the fact that the independent variable explains 95.8% of the behavior of the dependent variable was highlighted. Finally, in measuring the level of teaching performance, the 108 teachers evaluated indicated that the IEDDCC objectively measures the construct for which it was designed.

Psychometric, Reliability, Validity, Measurement

Resumen

El objetivo de este trabajo consistió en exponer y validar las propiedades psicométricas de un Instrumento adecuado para evaluar el desempeño docente en la conducción de clase (IEDDCC); el estudio se consideró de tipo instrumental y para la recolección de datos se utilizó una muestra de tipo intencional de 108 figuras académicas de educación básica. El resultado en la medida de las propiedades psicométricas del Instrumento indicaron una fiabilidad del alfa de Cronbach de 0.964 y, en la validez de constructo efectuada a través de la prueba de correlación “dominio total”, se obtuvo un valor del coeficiente Rho de Spearman de 0.978, valores considerados como bastante aceptables. Respecto a la prueba de validez confirmatoria que se realizó a través de la prueba de regresión lineal, también se obtuvo información que avala estos resultados; entre ellos se destacó el hecho de que la variable independiente explica en un 95.8% el comportamiento de la variable dependiente. Por último, en la medida del nivel de desempeño docente, los 108 profesores evaluados indicaron que el IEDDCC mide con objetividad el constructo para el que fue diseñado.

Psicometría, Fiabilidad, Validez, Medición

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Introduction

The instrument for evaluating teacher performance in classroom management was derived from the Instrument for measuring teacher learning as a product of the performance evaluation process (IEAD) (Ochoa and Cháidez, 2020), specifically from the dimension "Classroom management". The construction of the IEAD was based on the operationalization of the dimensions of two instruments:

a) The Classroom Observation Instrument (IOC), which was an adaptation of the Tsang Hester Observation Rubric (THOR), designed to measure teacher performance in the dimensions "classroom management", "teaching management" and "learning assessment", "[…] is based on the study by Tsang (2004), the original version of which has already been evaluated and validated by Good (2006)", (Contreras, et al., 2013, p. 93). The IOC was adopted to the Chilean educational context and was constructed with the objective of being able to determine the level of teacher performance practiced in that context.

b) The instrument Perfiles Parámetros e Indicadores (PPI), proposed by the Secretaría de Educación Pública, (SEP, 2018a).

The structure of the IEAD was made up of 43 items measurable through a Likert scale, distributed as follows: 16 items in dimension 1, "classroom organization" (the name of this dimension was changed from "classroom management" for reasons favorable to the Mexican context); 17 items in dimension 2, "classroom management" and; 10 items in dimension 3, "evaluation of learning".

The IEAD was constructed to measure teacher learning as a product of the performance evaluation process at the three levels of basic education and, in order to obtain the appropriate information, the instrument was applied to 108 academic figures who were in charge of evaluating one of their teachers; among these figures were Sector Heads, Supervisors, Principals, Assistant Principals and Technical Pedagogical Advisors;

All of them knowledgeable about the work that their teachers must perform and were performing at the time of the evaluation. The response to the items of the dimensions of the IEAD were rated with a Likert scale of four levels, adequate to measure the teacher's performance; that is, his or her intervention in the classroom in promoting student learning.

Specifically, the information collected with the items of the dimension "classroom management" measures the teaching performance related to the way of managing the class, and therefore, facilitating the learning of their students; for this reason, this dimension was constituted as an Instrument to evaluate the teaching performance in classroom management (IEDDCC), (see annex number 1). The Likert scale used to evaluate teaching performance included "fair", "good", "very good" and "excellent" performance levels.

Problem statement

Based on the exposed background, this research work consisted in exposing and validating the psychometric properties of the IEDDCC; the first foundation that validated the idea of proposing it as an independent instrument to the IEAD, was the observation described by De la fuente (2019):

"If there are 'n' factors, it is interpreted that the original instrument can be decomposed into 'n' instruments (each composed of all items), although in each instrument the items have a different 'specific weight' depending on their relationship to the factor: If we find, for example, three factors, this means that we can decompose the original instrument into three instruments; each one is composed of all the items, but in each instrument the items have a different specific weight according to their relationship with each factor (p. 3).

In the measurement of the psychometric properties of the IEAD, a Cronbach's alpha reliability of 0.98 was obtained, while the construct validity was developed through the total domain scale correlation test, confirming the validity of the instrument by means of the multiple linear regression test. One of the relevant results that gave rise to the study in this paper was the equation of the regression model obtained in the Student's t-test.

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In order to determine the construct validity of the IEDDCC, it was necessary to present the results of the IEAD construct validity test; specifically, the confirmatory validity obtained with the multiple regression test, highlighting the determination of the model equation through the Student's t-test and expressed in algebraic terms as follows:

$$y = 0.087 + 1.023x_1 + 1.045x_2 + 0.983x_3$$

The information implicit in the equation of the regression model allowed inferring the existence of linear independence between the dimensions of the IEAD, and therefore, the possibility of treating them as independent instruments at the same time; in these circumstances, the objective of this research work was to expose and validate the psychometric properties of reliability and validity of dimension 2, "classroom management"; and to be considered as a valid instrument to evaluate teacher performance in classroom development.

A complementary work that contributed to the achievement of the objective of this research work was the presentation of the results of the evaluation of the teaching performance in classroom management shown by the 108 teachers evaluated.

Objective

To present and validate the psychometric properties of the Instrument for Evaluating Teacher Performance in Classroom Conduct (IEDDCC).

Justification

The research work was carried out to create the IEDDCC, an instrument that emerged from the second dimension of the IEAD. The construction of the IEDDCC is considered important because its independence makes it possible to evaluate the performance of teachers in the development of their educational practice in the classroom or classroom management, a fundamental aspect in the educational process that is directly related to the facilitation of learning promoted by the teacher.

On the other hand, the results of the application of the IEDDCC can benefit all those academic figures who wish to know the performance of teachers in relation to their way of conducting the teaching-learning process with their students, information that can be fed back to the teachers subject to evaluation and undertake joint actions that contribute to improve performance in this dimension of learning.

Theoretical Reference

Teaching practice

The teacher's educational practice in the classroom has a fundamental effect on the generation of student learning; for this reason, the teacher must be committed to the development of strategies, resources and methodologies that make it possible for the contents of a curriculum or course to contribute to the achievement of the proposed objectives, that are meaningful and applicable to their environment.

Research on teaching effectiveness has provided a wealth of information on how classes are developed and how teachers work to ensure that their students learn above and beyond what would be expected in their context (Murillo, Hernández and Martínez, 2016, p. 56).

One of the fundamental aspects in the educational process in the classroom is communication, since it is the way to put a message to the consideration of the students, the exchange of meanings, the presentation of arguments, the promotion of debate for the search of consensus and the clarification of misunderstandings, among others. In this context, the panorama of content is broadened and students gradually re-signify their previous conceptualizations; in this way and under these conditions, language serves to represent and communicate meanings and is constituted as a didactic resource and a teaching and learning strategy.

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The most recent international and national studies on educational communication define it as a process that is closely related to the educational work of the teacher, involving different forms of interaction, exchange of information and joint elaboration of meanings among participants as an essential characteristic of the teaching process (Sardiñas, Domínguez and Reynoso, 2020, p. 20).

In the educational action, the communicative relationship between teacher and student is essential and it must be reciprocal and unidirectional; in this regard, with the development of technologies and remote education, there has been a loss of face-to-face communication between educational agents; however, regardless of the classroom environment, clear communication can lead to the facilitation of learning for students.

Teachers, who are responsible for providing educational services in each of their classrooms, have found it necessary to assimilate digital competencies in order to meet the learning needs of their students (Alcántara, 2022, p. 26).

The educational process

In the educational activity within the classroom, teachers approach their teaching-learning processes based on some reference theory that supports the development of some educational model that is applied with the purpose of facilitating the learning of their students, so that the appropriation of knowledge allows them to develop academic activities, solve problems that arise and evaluate their results; "(...) this process is pedagogically based, in accordance with modern currents, on the purpose that the person learns and achieves the expected learning outcomes" (Serrano, 2017).

In this educational process, external support within the classroom also has a strong influence, support that consists of strengthening the teacher's pedagogical management and that can lead to better results as a result of the socialization of academic content;

One of the figures that provides this service is the technical-pedagogical support who, together with the management function, must act as an advisor of the educational practice based on the follow-up of actions of the Improvement Route, that is, as external support that identifies the strengths and areas of opportunity in the schools. Therefore, these figures should be oriented to develop classroom observation abilities, with technical rigor and ethical professionalism, as well as supervisory skills with a pedagogical guideline and specific formative feedback, so that from them they derive recommendations for classroom and school practice (DOF, 2017). With the purpose of evaluating the results of the educational activities developed in class, some studies have highlighted the importance of the feedback action of the knowledge approached, since this is a fundamental part of the teaching-learning process generated in class, a space in which aspects of self-evaluation and co-evaluation converge in a natural way in favor of learning; in this regard, the literature review indicates a greater production in the study of students' perceptions in feedback activities, this can be explained due to the sustainable approach that suggests the idea of the student as an autonomous learner, hence the considerations linked to factors such as motivation, emotionality and interest. (Quezada and Salinas, 2021, p. 234).

Method

Research design

According to the objective and characteristics of this research work, the study was considered instrumental in nature since "(...) all studies aimed at the development of tests and devices, including both the design (or adaptation) and the study of their psychometric properties, are considered to belong to this category" (Montero and León, 2007, p. 855).

Participants

The study sample used to validate the IEAD and consequently the IEDDCC, was 108 academic figures who were selected as evaluating participants, among them: Sector Heads, Supervisors, Directors, Assistant Directors and Technical Pedagogical Advisors; all of them assigned to the SEP.

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Even though the number of elements included in the sample was quite acceptable, in addition to providing a high degree of homogeneity, the economic cost and geographical dispersion of the participants was an obstacle to access more of them; under these conditions, the selection of the sample was "intentional"; this procedure is conceptualized by Otzen and Manterola (2017), as follows, "It allows selecting characteristic cases from a population by limiting the sample only to these cases. It is used in scenarios where the population is highly variable and consequently the sample is very small" (p. 230).

Information analysis tool

The classification and organization of the data and the psychometric tests of the IEDDCC were carried out with the use of the Excel spreadsheet and the SPSS statistical program version 22, respectively.

Operational variable scores

The scores of the operational variables used in the study can be found in the Appendices section (see appendix 2), and were coded for the SPSS program as follows:

a) DESDOCEN (teaching performance), contains the total score for each of the 43 IEAD items.

b) D2COCLAS (dimension 2, classroom management) contains the total score of each of the 17 items of dimension 2.

Based on the D2COCLAS score, the range of scores for each level of the Likert scale was determined; this classification was carried out by means of an arithmetic operation that allowed locating the level of teaching performance in classroom management; the score that specifies the level at which each evaluated teacher was placed was coded with the name DEDOCOCL (teaching performance in classroom management) and can be found in the Appendices section (see appendix 3).

Reliability test

The reliability of an instrument is the reproducibility of results obtained by a measurement procedure; it can be interpreted as the degree of stability achieved in the results when a measurement is repeated under similar conditions.

Reliability or reliability refers to the consistency or stability of a measurement. A technical definition of reliability that helps to solve both theoretical and practical problems is one that starts from the investigation of how much measurement error exists in a measurement instrument, considering both systematic variance and variance by chance (Kerlinger and Lee, 2002, cited by Quero, 2010, p. 248).

To measure the reliability of the IEDDCC, the response given to its 17 items by the 108 participants was used; the test used was Cronbach's alpha coefficient, appropriate to the Likert scale of the questionnaire.

IEDDCC construct validity

The construct validity test of the IEDDCC was also performed based on the "total domain" correlation tests of the scale; this test is validated by Morey (2011) who states that "The evaluation of construct validity is multiple, and includes: "(...) correlational studies with a wide variety of relevant measures" (p. 10).

For the particular case of the IEDDCC, the correlational test was performed between the DESDOCEN score or "total mastery" of the scale and the D2COCLAS score; in the application of the test, Spearman's rho statistic was used, which is appropriate for variables whose scores do not obey a parametric distribution, as is the case of the variables treated.

To determine the existence of correlation between interval or ratio type variables with a nonparametric distribution, the following observation was considered: "The term nonparametric statistics refers to statistical methods that do not require the specification of an assumption about the distribution from which the sample data come to make inferences about the population." [Cáceres & Hernández, 2006, cited by Mondragón, 2014, p. 99].

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The correlation test between the variables indicated, was determined based on the following approach:

Hypothesis contrast:

H_o : There is no correlation between X and Y
H_1 : There is correlation between $X\ y\ Y$

The decision rule:

$if\ "p"\ value\ \leq \alpha, reject\ H_o$

Validity test confirmation

In order to complement the construct validity of the IEDDCC, a simple linear regression test was performed using the score of the dependent variable DESDOCEN and the score of the independent variable D2COCLAS.

The simple linear regression test consists of calculating the equation corresponding to the line that best describes the relation between the response or dependent variable and the explanatory or independent variable.

Regression analysis is a statistical technique used to investigate and model the relationship between an explanatory variable (X) and a response variable (Y). In order to perform such an investigation, a model must be postulated that is made up of a deterministic component and a random component. The first is a function between the variables; the second considers the linear function y=β_0+β_1 X_1, which represents the equation of the line in the plane (Lavalle, Micheli and Rubio, 2006, sp).

To evaluate the regression model of DESDOCEN and D2COCLAS scores, the results of three tests were analyzed:

a) ANOVA hypothesis test, the purpose is to verify if the independent variable contributes information in the explanation of the dependent variable; the regression model approach and the hypothesis test is as follows:

$Y = a + bx + e$

$H_O = \beta_O$

$H_i \neq \beta_O$

Hypothesis contrast:

H_O: $There\ is\ no\ association\ between\ X\ and\ Y$

H_i: $There\ is\ an\ association\ between\ X\ y\ Y$

The decision rule:

$if\ "p"\ value\ \leq \alpha, reject\ H_o$

b) Student's t-test, useful to determine the coefficients of the regression model and the significance of the information provided by the independent variable (IV); the regression model approach and the hypothesis test are as follows:

$H_O = 0$

$H_i \neq 0$

Hypothesis contrast:

H_O: $The\ independent\ variable\ does\ not\ provide\ significant\ information$

H_i: $The\ independent\ variable\ provides\ significant\ information$

The decision rule:

$if\ "p"\ value\ \leq \alpha, reject\ H_o$

c) The third test consisted of determining the coefficient of determination R^2, a statistic that reflects the extent to which the independent variable explains the behavior of the dependent variable.

Teaching performance in class management

An extra contribution to the validation of the IEDDCC was the result of the evaluation of the teaching performance in class conduction that the 108 evaluated teachers evidenced; this result was obtained through a Likert scale and its score was coded for the SPSS program as DEDOCOCL. The use of this measurement scale was similar to the one used by Martínez and Juárez (2019) in the validation process of an instrument, regarding the levels used they expressed the following: "A Likert scale from one to four (where one corresponds to the evaluation with the lowest score) was used to carry out the quantitative evaluation". (p. 45)

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The levels of the Likert scale are described in Table 2, which shows four levels of teaching performance in classroom management that teachers can observe in their educational practice.

Level of performance in class management	
1	Performance "regular"
2	Performance "good"
3	Performance "very good"
4	Performance "excellent"

Table 1 Scale to measure teaching performance in classroom management
Source. Own Elaboration

Results

Reliability test

Table 2 shows the result of the reliability test that was carried out with the 17 items of the IEDDCC, in which it can be seen that the value of the Cronbach's alpha statistic was 0.96, a number that indicates an excellent reliability of the instrument; this assessment is confirmed by the result obtained by Zambrano et al. (2015), who indicated that: "According to Cronbach's alpha coefficient, the internal consistency of the test is adequate since a value of 0.99 is obtained" (p. 32).

Reliability statistics	
Cronbach's alpha	N of elements
.964	17

Table 2 IEDDCC Reliability
Source. Own Elaboration

Construct validity

Total domain correlation result

Table 3 shows the result of the correlation test between the variables DESDOCEN and D2COCLAS; the value of the Rho coefficient is 0.978 and indicates that there is a very good correlation between the pair of variables.

Correlations				
			DES-DOCEN	D2CO-CLAS
Rho Sper	DES DOCEN	Coef correl	1.000	.978**
		N	108	108
	D2CO CLAS	Coef correl	.978**	1.000
		N	108	108
**. The correlation is significant at the 0.01 level				

Table 3 Correlational test result
Source Own Elaboration

Confirmatory validity result

Table 4 shows the result of the ANOVA test and according to the hypothesis contrast, the existence of association between the pair of variables was confirmed, indicating that the information of the independent variable is significant in the regression model.

ANOVA[a]					
Model		Sum of squares	gl	F	Sig.
1	Regression	102191.3	1	2426.1	.000[b]
	Residue	4464.7	106		
	Total	106656.1	107		
a. Dependent variable: DESDOCEN					
b. Predictors: (Constant), D2COCLAS					

Table 4 ANOVA test result
Source. Own Elaboration

Table 5 shows the result of the Student's t-test, according to the hypothesis contrast, it was confirmed that the independent variable contributes significant information to the regression model; on the other hand, the coefficients that define the model equation were also obtained.

Model				t	Sig.
		B			
1	(Constant)	3.101		1.352	.179
	D2COCLAS	2.597		49.25	.000

Table 5 Student's t-test results
Source. Own Elaboration

Table 6 shows the result of the test of the coefficient of determination R^2, according to the hypothesis contrast, it was confirmed that the independent variable explains the behavior of the dependent variable in 95.8 %.

Model	R	R square adjusted	Durbin-Watson
1	.979[a]	.958	1.78

Table 6 Test result R^2
Source. Own Elaboration

Results of the level of teaching performance

From the application of the IEDDCC, the final product was the level of teaching performance in classroom management shown by the 108 teachers evaluated.

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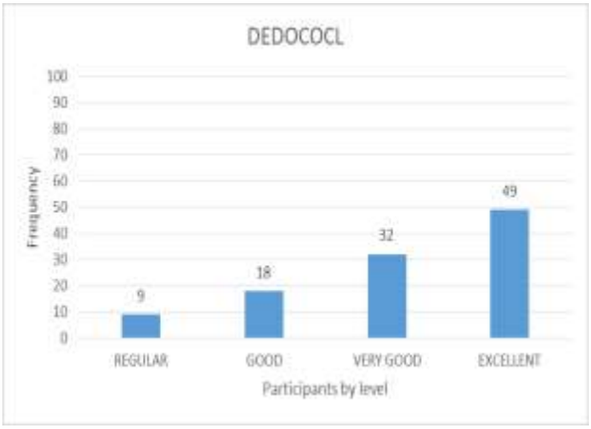
Table 7 shows the description of the result of the level of teaching performance in classroom management, with the following percentage values: a) 8.3% obtained a "regular" level of performance, b) 16.7% obtained a "good" level of performance, c) 29.6% obtained a "very good" level of performance and d) 45.4% obtained an "excellent" level of performance.

		Frec	% valid	% Accum
Valid	Regular	9	8.3	8.3
	Good	18	16.7	25.0
	Very good bueno	32	29.6	54.6
	Excellent	49	45.4	100.0
	Total	108	100.0	

Table 7 Level of teaching performance in classroom management
Source. Own elaboration

Graph 1 shows the data described in table 7.



Graph 1 Level of teaching performance
Source. Own Elaboration

Conclusions

The idea of setting the objective of validating the IEDDCC was based on the equation that resulted from the confirmatory validity study of the IEAD, the product of the multiple linear regression test to which it was subjected; this equation already indicated the existence of association between variables, but according to the value of the coefficients of the independent variables, it also indicated their linear independence. This observation was evident in the contrast between the psychometric properties of reliability and validity of both instruments, the latter expressed in the correlation test; the result of the comparison was as follows:

a) In the Cronbach's alpha reliability test; the result for the IEAD was 0.984 and for the IEDDCC was 0.964; the latter value registered a decrease in the alpha index of 2%, determining the reliability of the IEDDCC as "excellent".

b) b) Construct validity was performed with the "total domain" correlation test using Spearman's Rho coefficient; the result between both variables indicated the existence of an "excellent" level of correlation.

c) c) The confirmatory validity test was performed by simple regression, and indicated three important results: 1) the existence of an association between variables; 2) the significance of the information between variables and, 3) that the independent variable explains the behavior of the dependent variable by 95.85%, a quite acceptable value.

Based on the results obtained in the measurement of the psychometric properties of the IEDDCC, it was affirmed that the instrument is reliable and valid for measuring the level of teaching performance in classroom management.

On the other hand, in the analysis of the results obtained by the IEDDCC as a result of its application to the 108 academic figures that evaluated their teachers, it was observed that the results obtained are close to reality, that is to say, 25% of the teachers classified in a level of teaching performance between "regular" and "good"; a similar value of 29.6% registered a level of "very good" performance and 45.4%, equivalent to 49 of the 108 teachers evaluated, showed an "excellent" performance.

Another important characteristic of the IEDDCC is the simplicity in the structure of its items, as well as the number of its elements, an aspect that motivated the independence of the IEAD; in addition, the base indicators of the items allow the evaluation of this construct at practically any educational level.

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ANNEXES

Instrument to evaluate teacher performance in classroom management (IEDDCC)					
Teacher performance level 1 = Performance "regular" 2 = Performance "good" 3 = Performance "very good" 4 = Performance "excellent"					
No	**ítem**	**1**	**2**	**3**	**4**
1	Does the teacher identify the characteristics of subject didactic approaches in learning activities?				
2	Does the teacher relate the learning contents of the subjects to the achievement of the educational purposes?				
3	Does the teacher relate his/her teaching intervention to the corresponding expected learning?				
4	Does the teacher relate his/her teaching intervention to the educational needs of his/her students?				
5	Does the teacher relate his/her teaching intervention to the didactic approaches of the subjects?				
6	Does the teacher use didactic strategies to help students develop cognitive abilities?				
7	Does the teacher diversify the use of didactic materials to achieve his/her educational purposes?				
8	Does the teacher elaborate specific didactic material for the development of its contents?				
9	Does the teacher use didactic material supported by technology?				
10	Does the teacher demonstrate a good attitude and generate guidelines to drive the rhythm of the class?				
11	Does the teacher use cooperative learning methods in working with his/her students?				
12	Does the teacher use learning workshops in working with students?				
13	Does the teacher use didactic strategies to help students learn based on their prior knowledge?				
14	Does the teacher use didactic strategies to help students learn among peers?				
15	Does the teacher use didactic strategies so that students learn with the participation of all?				
16	Does the teacher master the contents of the Primary Education subjects?				
17	Does the teacher propose a sequence of educational content to facilitate the learning of his/her students?				

Annex 1 Instrument IEDDCC

PART	DES-DOCEN	D2CO-CLAS	PART	DES-DOCEN	D2CO-CLAS
1	133	48	55	129	49
2	61	23	56	152	60
3	140	52	57	107	42
4	106	40	58	124	45
5	127	51	59	135	52
6	122	46	60	93	31
7	107	37	61	160	59
8	158	57	62	127	47
9	91	32	63	154	57
10	105	38	64	117	44
11	128	51	65	93	31
12	118	47	66	115	41
13	66	33	67	157	57
14	142	54	68	155	57
15	67	29	69	150	53
16	103	36	70	153	58
17	52	19	71	151	55
18	54	19	72	81	29
19	144	55	73	139	53
20	114	42	74	80	29
21	149	56	75	135	51
22	108	39	76	102	36
23	104	40	77	103	37
24	121	44	78	141	55
25	126	46	79	159	58
26	98	38	80	136	52
27	83	31	81	71	20
28	119	43	82	92	35
29	62	22	83	74	25
30	54	19	84	124	52
31	162	59	85	132	52
32	132	49	86	109	41
33	152	57	87	128	46
34	100	37	88	68	31
35	103	45	89	56	19
36	114	42	90	50	17
37	135	57	91	92	35
38	128	51	92	48	17
39	97	39	93	45	17
40	126	45	94	96	36
41	118	46	95	51	19
42	142	49	96	61	24
43	71	29	97	121	42
44	126	49	98	134	53
45	146	56	99	101	40
46	150	54	100	64	26
47	120	42	101	69	31
48	136	49	102	122	46
49	130	46	103	146	51
50	131	47	104	76	27
51	117	42	105	115	42
52	137	50	106	105	41
53	150	57	107	58	23
54	133	52	108	99	37

Annex 2 Scores DESDOCEN and D2COCLAS

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PART	DEDO-COCL	PART	DEDO-COCL	PART	DEDO-COCL
1	4	37	4	73	4
2	2	38	4	74	2
3	4	39	3	75	4
4	3	40	3	76	3
5	4	41	4	77	3
6	4	42	4	78	4
7	3	43	2	79	4
8	4	44	4	80	4
9	2	45	4	81	1
10	3	46	4	82	3
11	4	47	3	83	2
12	4	48	4	84	4
13	2	49	4	85	4
14	4	50	4	86	3
15	2	51	3	87	4
16	3	52	4	88	2
17	1	53	4	89	1
18	1	54	4	90	1
19	4	55	4	91	3
20	3	56	4	92	1
21	4	57	3	93	1
22	3	58	3	94	3
23	3	59	4	95	1
24	3	60	2	96	2
25	4	61	4	97	3
26	3	62	4	98	4
27	2	63	4	99	3
28	3	64	3	100	2
29	2	65	2	101	2
30	1	66	3	102	4
31	4	67	4	103	4
32	4	68	4	104	2
33	4	69	4	105	3
34	3	70	4	106	3
35	3	71	4	107	2
36	3	72	2	108	3

Annex 3 Score DEDOCOCL

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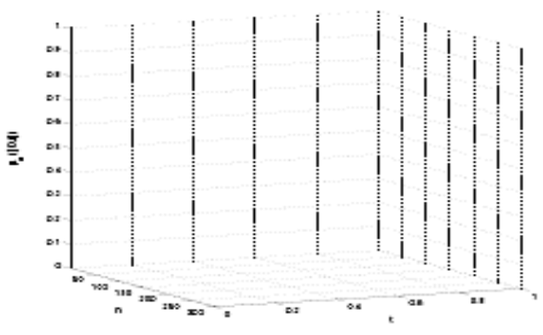

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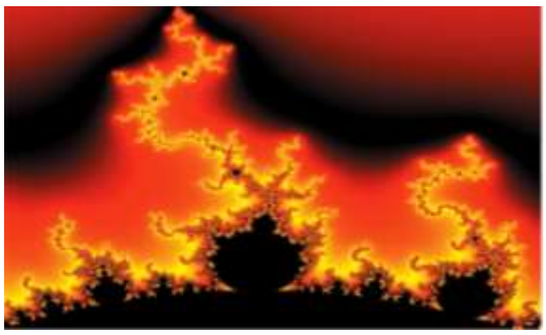

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