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Journal Basic Education

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The works must be unpublished and refer to topics of Basic education, higher education, higher education, comprehensive education reform, national agreement for modernisation, basic education and other topics related to Humanities and Behavioral Sciences.

Presentation of Content

In the first article we present, *Per-Q as an intervention project in virtual education for virtual learning environments* by Martínez-González, Fernando Eduardo, Macías-Brambila, Hassem Rubén, Rodríguez-Jiménez, Liza Mayela and López-Laguna, Ana Bertha, with adscription in the Universidad de Guadalajara and Universidad Tecnológica de Jalisco, as the following article we present, *Use of Kahoot, Quizizz and Educaplay as formative assessment for student learning in elementary school*, by Domínguez-Gutú, Jesús, Trejo-Trejo, Gilberto Abelino, Gordillo-Espinoza, Emmnauel and Constantino-González, Fernando Exiquio, with adscription in the Universidad Tecnológica de la Selva, as the following article we present, *Educational Lag in Higher Secondary Education Institutions in Ixtapaluca, Valle de Chalco and Chalco* by Aldape-Enriquez, Elsa Georgina, Flores-Valtierra, José Juan, Mojica-Galaviz, Luis Alberto and Valdés-Torres, Arturo, with adscription in the Tecnológico Universitario del Valle de Chalco, as the following article we present, *Soft skills in the graduate profile for the professional development of engineers* by Moreno-Aguilar, Ma. Antonia, Sánchez-López, Guillermina, Luna-Aguirre, Jaime and Reyes Oliver, Irma, with adscription in the Universidad Tecnológica de Puebla and Instituto Tecnológico de Puebla, as the following article we present, *Identification of priority cases for attention to the academic performance of students by subject* by Fernández-Mena, Ana Laura, Torres-Magaña, María Patricia, Hernández-De La Rosa, Francisco Alberto and Rodríguez-Fernández, Manuel Antonio with adscription in the Tecnológico Nacional de México/Instituto Tecnológico de Villahermosa, as the last article we present, *Gamification for the development of soft skills in the engineering area* by Zamora-Quintana, Laura Angélica, Vázquez-De León, María del Sol, García-Martínez, Juan Marcos and Sánchez-Huerta, María Magdalena, with adscription in the Universidad de Guadalajara.

Content

Journal Basic Education 8[19]1-11: e1819111
Article

Per-Q as an intervention project in virtual education for virtual learning environments

Per-q como proyecto de intervención en educación virtual para ambientes virtuales de aprendizaje

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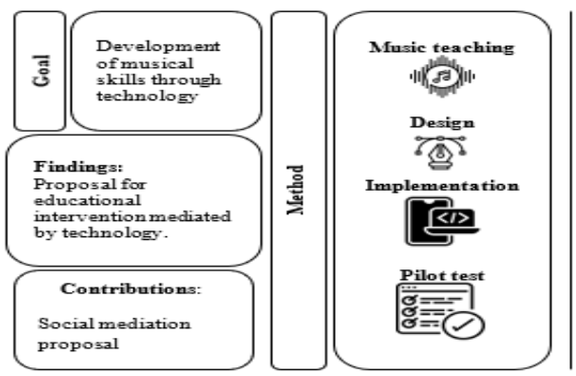
Abstract

This article describes the methodological process in the design, implementation, and evaluation of Per-Q as an intervention project for educational practice in music teaching through the design of multimedia educational resources, social networks, software development and instructional design for virtual learning environments. Considering rhythm as the main element, based on the Rhythmic Dalcroze, Dum-Dum, How to Play, Slap Happy and Rhythm stories methods, as methods that incorporate activities with movements, the game as a didactic element, improvisation, and the possibility of doing it without musical instruments implemented through traditional, constructivist and critical musical didactics approaches. Project aimed at a children's audience based on Jean Piaget's Theory of Cognitive Development and the stage of concrete operations, where initial rhythmic learning is associated with logical operations such as serialization, numbering and classification that are presented at the ages of the target audience. and that contemplates the possibility of implementing social mediation models in existing study programs at various levels of education.



Musical education, Virtual learning environments, Didactic approaches

Resumen

El presente artículo describe el proceso metodológico en el diseño, implementación, y evaluación de Per-Q, proyecto de intervención de la práctica educativa en la enseñanza musical, a través del diseño de recursos educativos multimedia, redes sociales, desarrollo de software y diseño instruccional para ambientes virtuales de aprendizaje. Considerando el ritmo como elemento principal, el proyecto está basado en los métodos Rítmica Dalcroze, Dum-Dum, How to Play Slap Happy y Ritmo historias, los cuales incorporan actividades con movimientos, el juego como elemento didáctico, la improvisación y la posibilidad de realizarlo sin instrumentos musicales, todo implementado a través de enfoques de la didáctica musical tradicional, constructivista y crítico. Proyecto dirigido a un público infantil, con edades entre 7 y 12 años, Per-Q está también sustentado en la Teoría del Desarrollo Cognitivo de Jean Piaget y la etapa de operaciones concretas, en donde los aprendizajes rítmicos iniciales se asocian con operaciones lógicas como la seriación, numeración y clasificación que se presentan en las edades del público objetivo y que contempla la posibilidad de implementar modelos de mediación social en los programas de estudio existentes en los diversos niveles de educación.

Educación musical, Ambientes virtuales de aprendizaje, Enfoques didácticos

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Introduction

Humanity has found in the use of new technologies a great tool for its educational development. Technological advances in recent decades have significantly impacted the curriculum of existing study programs at all levels of education.

Consequently, music teaching has not been the exception since we find that different approaches to musical didactics coincide with the various models of social mediation that are developed both in virtual learning environments (VLE) and in education.

Starting from the various approaches to didactics we find ourselves first with the traditional approach that contemplates traditional or "classical" models, such as the so-called musical academic model, where theoretical learning is separated from practical learning and musical practice is worked through imitation and repetition (Marín-Liébana et al., 2021).

This approach is related to the behaviorist mediation model in which students are led to concrete and specific objectives and the replication of behaviors through instruction and reinforcement. Secondly, we identify that the constructivist approach contemplates an active role of the student through their own experience and interaction with the environment that coincides with the cognitive paradigm of mediation that guides students to the resolution of significant activities and practical experiences (Ramírez and Chávez, 2021).

It is also associated with the humanistic model (both didactic and mediational), where the student is placed at the center and his or her needs and interests are attended to, promoting self-evaluation and self-criticism and the student's responsibility in his or her own learning process.

Finally, we distinguish the so-called critical approach to musical didactics that is based on the socio-critical paradigm oriented towards action and transformation where "the teacher is a transformative intellectual, while the student is an active subject who constructs his reality in a socio-economic way constructivist from social interaction" (Marín-Liébana et al., 2021, p. 18).

As Giroux (2001, cited in García-Vélez and Maldonado, 2017) points out, education is above all a socialization process in which we learn to be citizens, relating to the environment in different sociocultural spaces. The social construction of learning dates to Vygotsky's social constructivism, which considers that human development occurs in a social process.

Vygotsky establishes that cultural aspects as a manifestation of the social are determinants in the cognitive development of the person, his theory is centered on the genetic law of cultural development, which establishes that every cognitive function appears first on the social level, understood as the immediate environment and then on the individual psychological level (Zapata-Ros, 2015). In this way, musical learning can be presented as a process of social and cultural formation.

From a constructivist mediation, the student's own learning experience is involved in the student's process through interaction and participation in accordance with Vygotsky's theory. The relationship between the approaches of musical didactics with the paradigms of social mediation opens new paths in the implementation of musical education in virtual environments.

Calderón et al., (2019), establish that musical education throughout history has been characterized by face-to-face teaching in which a teacher transmitted his knowledge in an almost mystical way to his disciples, creating a bond of companion and accompanied through the path of knowledge.

Although this was understandable and laudable in past times, in the 21st century it may be, if not obsolete, then lacking in ideas that allow us to take advantage of the resources that technological advances offer.

Regarding music and rhythm as part of the comprehensive training of people, the Multiple Intelligences Model is considered, proposed by Howard Gardner in 1983, where the skills that people possess are grouped into at least seven or eight categories or "intelligence". This model revolutionized the concept of unitary human cognition, speaking of diverse intelligences in all human beings, with the possibility of developing and influencing the teaching-learning process in a different way.

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"Each one develops in a particular way and at a particular level, a product of the biological endowment of each person, their interaction with the environment and the culture prevailing at their historical moment. We combine them and use them to different degrees, in personal and unique" (Gardner, 1995).

Among the intelligences established by Gardner is musical intelligence, "made up of people sensitive to the elements of music, which are rhythm, melody, harmony" (Paniagua and Vega, 2008). This intelligence is related to the skills and affinities that people have with respect to music and other forms of rhythmic expression.

Musical intelligence involves emotional development that promotes empathy and the expression of feelings, a process that involves knowledge and improvement of language, and its expression, which includes sociocultural aspects of identification (Rodríguez et al., 2016).

Furthermore, we must keep in mind that when music is performed in a group, and even more so if it is improvised, a high level of understanding of the other, empathy, and verbal and non-verbal expression is required (Davis, 1990).

Now, among the main elements of music we find the following:

- Rhythm, which for Pérez-Aldeguer (2014) is a construct that encompasses both tempo (relative unit of measurement)
- The pulse (as a regular unit of measurement)
- Metric (a specific grouping of sounds with their own meaning, a term inherited from poetry)
- The beat (alternation of strong and weak accents)

Other authors such as Lussy (1982) establish the concept of rhythm as “the order in time or space”, or Vignal (1997) as the “ordering of sounds in time”. For Jaques-Dalcroze (cited in Pérez-Aldeguer, 2014) rhythm is a vital principle, it is movement and favors the nervous system. Rhythm is also considered a factor of social inclusion and a unifying element between cultures and times.

“Rhythmic education and percussion provide people with an ideal means to develop psychomotor skills, body schema, neuromotor behaviors, temporal space structuring, perceptual organization and psychomotor disorders, among others” (Pérez- Aldeguer, 2014). The different traditions of rhythmic musical teaching allow an approach to multi and intercultural education. For Pérez-Aldeguer (2014), inclusive education comes to be the set of principles that guarantee that the student, regardless of his or her characteristics is a valuable person; It's about an attitude.

Multiculturalism, then, refers to the presence of several cultures in the same society and assuming it means recognizing the right to difference as an educational and social enrichment (Imbernón, 2000). Music can be used as a pedagogical resource that promotes acceptance and recognition of cultural diversity.

Hemsy de Gainza (2004) states that "in European musical pedagogy, the learning of rhythmic-body games and ethnic (especially of African origin) and popular dances" is common.

It also observes that in some Latin American countries children and young people learn music through various popular practices such as singing, dance, games, etcetera, which include participation and bodily performance. Therefore, rhythmic teaching through Communication and Information Technologies (ICT) makes it necessary to develop technological tools considering a curricular design in accordance with the learning objectives and pedagogical development that is managed in an integral manner in the VLE, with the purpose of successfully acquiring the musical skills established by an educational program.

Methodology

The methodological process implemented for the project is based on the integration of an educational intervention proposal, which contemplates the recognition of rhythmic musical teaching through a Virtual Learning Environment (VLE), the delimitation of the target audience, the selection of the environment virtual learning, the design of the intervention, the definition of objectives, goals and indicators, as well as the definition of strategies and project programming, its implementation and evaluation.

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Rhythmic musical teaching

Derived from the COVID-19 pandemic, it was necessary for in-person music classes taught by different teachers to migrate to the virtual modality, generating a bias in the use of appropriate pedagogy by the teacher to teach his class, as well as in the elements appropriate to the curriculum contained in the program.

Once the diagnosis was carried out, in which the problems of online music classes were identified, the focus of the proposal was determined both in its main theme, the delimitation of the target audience and the ideal virtual environment for its implementation.

The importance of rhythm as the main element of music and as an example of practical musical learning is presented as an appropriate area for the main theme of the project, considering different aspects in the implementation of its teaching-learning processes.

By determining rhythmic musical learning as the central axis of the proposal a study was carried out of different methodologies in which play, improvisation and multicultural competencies are present as common elements such as Dalcroze rhythmics, the Dum-Dum program, How to play Slap Happy and Rimo Stories, a guide to learning rhythmic stories through musical improvisation.

The following similarities were found among the methodologies:

- Rhythm and movement. (Dalcroze Method, Slap Happy).
- Possibility of making rhythms with movements with parts of the body without having to have a musical instrument. (Slap Happy, Dum-Dum).
- Use of own symbols (Dum-Dum, Rhythm Stories).
- Using a drum pattern (Percussion) or a navigation pattern as rhythmic musical notation. (Dum-Dum, Slap Happy, Rhythm Stories).
- Game as a teaching element. (Dalcroze, Dum-Dum, Rhythm Stories).
- Multiculturalism, music and rhythm in different cultures. (Dum Dum, Slap Happy, Rhythm Stories).

Delimitation of the target audience

The activities of the methodologies, in which game dynamics are developed, can be easily implemented with children and young people.

Dum Dum is a method designed for primary school children, and the experiences compiled in the diagnoses of teachers Georgina Gómez and Héctor Aguilar, experts in the Dalcroze and Ritmo Historias methodologies, respectively, demonstrate the good practices of the methods in that sector. from students.

Ages 7 and 12 correspond to the ages of the stage of concrete operations established in Jean Piaget's theory of cognitive development, "concrete operations constitute the transition between action and more general logical structures that involve combinatorics and "group" structure. (Piaget et al., 2016) At this stage, children develop their operational schemes and can classify, order, and understand the notion of number.

The structuring of rhythm corresponds to the operations that make up the concept of the notion of time, established in theory: the series of events constituting the order of temporal succession, an adjustment of intervals between specific events, a source of duration, and a temporal metric. (which already acts in the system of musical units, long before any scientific elaboration), isomorphic of spatial metrics (Piaget et al., 2016).

Children between six and twelve years old are in the period of development in which they move from preoperative thinking to concrete operational thinking and in the maturation and progressive transformation towards a reflective awareness of structures.

From these ages, it is possible to introduce rhythmic activities that involve ostinatos (repetition of the same musical idea) and formulas that can be adapted to the possibilities of the children, considering each difficulty overcome to introduce new rhythmic elements (Meece, 2000).

Classification and serialization allow us to understand the order of the rhythm, both in the steps to execute it and to structure it.

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The notion of numbers from the perspective of serialization and the understanding of space, time and speed allows us to capture the rhythmic sense not only through repetition, and where the support of a visual representation can be auxiliary as a reference to develop a musical idea. rhythmic.

Selecting the virtual learning environment

The factor associated with the digital divide as part of the problem of users' limitations in digital skills and competencies can be addressed by selecting a platform that is easy to use, accessible and does not require high technological skills, such as Google Workspace, formerly known as G-Suite.

The variety of tools that Google offers allows on the one hand, to design activities and dynamics that do not imply advanced digital skills in students.

On the other hand, considering the characteristic environments of a virtual learning environment established by Peña (2014), the diversity of tools offers different alternatives for the development of the actions corresponding to each environment:

Sites: Development of the main page.
Classroom: Main platform with home section.
Calendar: Agenda information and dates.

Knowledge environment:
Classroom: Activities supported by resources.
Drive: Repositories, files, and content.
YouTube: Channel with content and activities.

Practical and collaborative learning environments:
Classroom: Space for activities and tasks.
Options for many "sharing" tools.

Evaluation and monitoring environment:
Classroom: Grades section.
Sheets: Spreadsheet for records and functions such as averages.

Management environment:
Classroom and Sites: Online services.

In addition to the benefits of accessibility and ease of use of Google Workspace as a virtual learning environment, the familiarization of students with Google tools was considered both in the State of Jalisco and at the national level. Since before the start of the pandemic, the Government of Jalisco already had an alliance with Google, and it is since the beginning of the health emergency that it has been established as the main platform to continue with classes.

Below is an excerpt from the Jalisco Government's press release detailing the actions and digitization process that occurred with Google: "Since 2019, the Ministry of Education and Google have been working hand in hand, with a strategy to that all basic education students and teachers could access a free Google Workspace for Education educational account, under the educational domain @jalisco.edu.mx, institutional accounts were created and delivered.

This process was considerably accelerated due to the pandemic, since more than 1.5 million accounts were created for students and just over 80 thousand for teachers.

It should be noted that, along with this process, digital training actions were implemented among the educational community, which resulted in a high adoption of Google tools" (Gobierno del Estado de Jalisco, 2022).

Design of the intervention proposal

Per-Q: Rhythmic learning music education program based on methodologies that promote active learning and play as an element in learning. Aimed at children between 7 and 12 years old through Google Workspace (G-Suite) tools.

The name Per-Q arises as a variant of the abbreviation of the word percussion, percu, changing the syllable cu for the letter Q as a phonetic relationship.

The project is based on rhythmic musical teaching as the main object of study, contemplating different methodologies and their implementation in virtual learning environments (VLE), as well as accessibility to learning and content, also considering the approaches of musical didactics and aspects of socio-constructivism for mediation in the VLE.

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Developed as a proposal aimed at children, gamification techniques and tools and the Multimedia Learning Theory are considered in the design of the activities and in the creation of original resources.

Objectives and indicators were designed consistent with the design of the intervention proposal.

General objective

Develop a music education program based on rhythmic musical learning methodologies and from various approaches to musical teaching for children from 7 to 12 years of age through Google Workspace and with the support of self-made digital resources.

Specific objectives

- Implement a first module of the program operating from the Google Workspace platform with Classroom as the main application.
- Implement asynchronous activities presented in video format as educational resources and implement them from Classroom.
- Create original digital resources as an interactive application.
- Use social networks and an official website as means of dissemination and socialization of the program.
- Register the application trademark with the IMPI.

Indicators

- The activities are based on theoretical and practical introductory topics of musical rhythm appropriate for the ages of the participants. ranging between 7 and 12 years old.
- The activities present characteristics of the rhythmic learning methodologies contemplated in the development of the project.
- Mediation in the virtual learning environment corresponds to the paradigms of mediation and its relationship with musical teaching approaches.
- The program is implemented on the classroom platform with the support of other tools from Google Workspace.

Definition of strategies

The definition of the strategies was carried out based on the creation of digital educational material for the development of digital resources considered with the cognitive theory of multimedia learning and gamification techniques. The strategies implemented where:

- Use of Cognitive Theory of Multimedia Learning
- Use of gamification techniques
- Use of interactive quizzes

Project schedule

The project was developed between June 2022 and April 2023. The proposal was proposed in three stages: 1. Preparation, 2. Implementation, and 3. Evaluation. Figure 1 presents evidence of the first stage, preparation.

Box 1

Activity (2022)	apr	may	jun	jul	ago
1-Enterprise image desing					
2- Production of activities and resources					
3.1. Purchase of pera.com.mx domain and hosting					
3.2 Website design on Google Sites					

Figure 1

Preparation stage.

Own elaboration.

Implementation

The implementation process initially considered the preparation stage, in this phase the project identity was created, materials were developed, the registration and opening of virtual spaces and complementary products were generated.

The second moment consisted of the development of the corporate image, Figure 2, providing the graphic identity of the project, which was defined considering the target audience, using primary colors and elements related to percussion, such as the letter Q in the shape of a drum.

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Box 2

Figure 2
Corporate image PER-Q
Own elaboration.

With the intention of establishing the Per-Q project as a formal musical education program, actions were carried out such as the registration of the trademark with the Mexican Institute of Industrial Property, IMPI, the purchase of a domain and hosting to host its own website, and a subscription to the Google Business Starter program.

The Per-Q brand was registered with the IMPI in August 2022, obtaining the resolution at the end of January 2023 and in which the use of the name is allowed for 10 years for educational purposes and musical materials.

In addition, the perq.com.mx domain was purchased in August 2022 through the GoDaddy platform, and then hosting services were obtained from the Tree Design company. For a simple but effective design of a custom website, the Google Sites tool, belonging to Google Workspace, was used, which can be linked directly to an established domain.

Another important action to consolidate the project was the subscription to the Google Business Starter package, with which it is possible to have a personalized Google account for the domain perq.com.mx, as well as the following benefits and extensions of a Google account:

- Video conferences of 150 participants and recording function.
- 2 TB of storage.
- Security and administration controls.
- Program content and activities.

As a program for children and with the objective of presenting practical concepts and activities, the following topics and concepts were established for the pilot module:

Program Unit - Content of Module 1

Concepts: rhythm and percussion.

- Percussion instruments.
- Movement symbols and use of percussion sheet music.
- Basic exercises of rhythms produced by the body and movements.

Multiculturality: rhythm and instruments of pre-Hispanic Mexico. The activities were developed considering the established themes of the first module and considering the following elements of musical teaching approaches:

- Traditional approach: specific objectives, instruction, separation of the theoretical from the practical in different activities.
- Constructivist approach: meaningful activities and practical experiences. Personalized attention to the student.
- Critical approach: active student, socialization of learning.

The multimedia principles of Multimedia Learning Theory were also considered, such as modality, divided attention, multimedia, and navigation. Another common element of the activities was the use of gamified resources. In each activity, the expected learning and elements of the project-based rhythmic learning methodologies present in each activity were specified.

Pilot test

During the months of February and March 2023, the pilot test of the first module of activities was implemented. With the registration of the Google Business Starter account and the official page, the activities were uploaded to the Classroom platform from the perq.com.mx account.

The Classroom platform, as a knowledge and practical learning environment within an EVA, allows, in its "Jobs" section, to publish activities presented as tasks. Each activity includes a section with instructions, a link to its respective video, sheet music, and delivery date.

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The next step in the implementation of the project was the dissemination of the program. Per-Q's social networks on Facebook, Figure 3, and Instagram were recorded. The module was offered free of charge through the program's social networks and was shared by word of mouth with potential interested parties.

Box 3

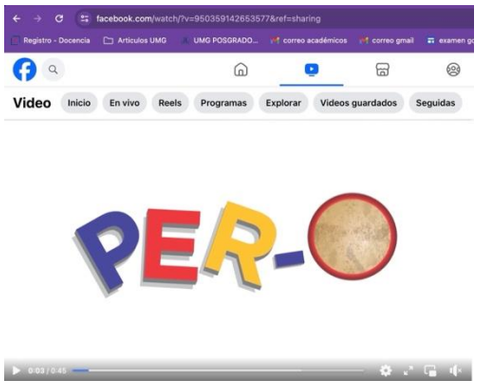

Figure 3
Promotional video for social networks
Own elaboration.

For registration, parents, or guardians of interested students were asked to complete a Google form. Among the enrolled students, two neurodivergent children participated, both on the autism spectrum, which was also presented as an opportunity to test the implementation of the program with students with special educational needs.

The course was carried out asynchronously from February 20 to March 5, 2023. Throughout the days in which it was held, notices and messages were published to follow up and support participants.

The activities were open throughout the duration of the course, so that participants could do them in their own time and at their own pace. On March 5, the activities were completed, thus closing the implementation of the project.

Assessment

In the context of the project, the evaluation model of Virtual Learning Environments (VLE) that was considered most appropriate was Marshall and Shriver's Five Level Evaluation Model, which places special emphasis on the teacher as a dynamic agent of training in virtual environments. (Rubio, 2003).

The five levels of the model are the following:

- Teacher: teacher capacity in online training.
- Course materials: in relation to the level of difficulty, relevance, interest, or effectiveness.
- Study plan: evaluation of contents.
- Course modules: based on previous levels.
- Learning transfer allows determining to what extent the course manages to transfer the acquired knowledge (Rubio, 2003).

The digital competencies and skills reflected in the creation and production of resources, the relationship of the study plan with the established objectives of the program, as well as the design of the modules and their contents, are part of the teaching work that can be evaluated following the Model by Marshall and Shriver.

Results

Derived from the information obtained from the observation guide instrument, carried out by professionals in the field of music teaching, the objective of implementing a first module of the program was achieved operating from the Google Workspace platform in the classroom, correctly integrating elements pedagogical and technological according to the designed program and the target audience.

The results of the evaluation according to the Marshall and Shriver model show that the body movement activities inspired by rhythmic methodologies were attractive to the students, as well as the video of pre-Hispanic instruments that promotes multicultural competencies, therefore it was achieved the development and implementation of a program with activities based on the revised rhythmic musical learning methodologies and their common elements. Also considering that the levels evaluated were appropriate for the characteristics of the project.

The Per-Q project implemented practical learning in virtual environments with original resources, taking rhythm as the main element and relying on methodologies that propose creative and accessible ways of carrying out learning.

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The rhythmic musical teaching methods based on the proposal were Dalcroze Rhythm, the Dum-Dum Program, How to Play, Slap Happy and Rhythm Stories; elements and characteristics present in the methods, such as activities with movements, the game as a didactic element, improvisation, dispensing with musical instruments to be able to play rhythms and a multicultural approach, fulfilled one of the objectives expressed in this research work.

Conclusions

Based on the results of the evaluation, it is concluded that the implementation of the proposal demonstrates that the project has great strengths, among which stand out a solid theoretical base, an innovative proposal and mastery of digital competencies by the team involved to carry out and design quality products and resources suitable both for the public and for use and integration in virtual learning environments.

The choice of "Google Workspace" as a virtual environment is based on its accessibility and its variety of complementary tools that are also easy to use, in addition to the familiarization of users with the Classroom platform, established by public policies at the federal and state levels such as the main platform for the educational field.

Through the diagnoses and case studies presented in the research, the lack of appropriate methodologies and/or strategies to implement practical musical learning in virtual music education environments could be established as a main problem.

Although the target audience was delimited in the formulation of the proposal, the implementation and evaluation demonstrate a whole area of opportunities in aspects of inclusion, considering students with special educational needs when producing the resources and materials.

On the other hand, the project must be constantly updated with respect to the way in which new generations act and interact in virtual spaces to produce more attractive resources that generate greater interest in the public, considering the speed with which the user relationships with technology.

The main weakness of the project was that the target audience, boys and girls, is a sector that does not have autonomy in its decisions and that depends on the decisions of its parents or families to be able to carry out activities related to courses or extracurricular classes.

At the time of offering and promoting the course, information was only obtained about the perception of adults and their criteria for deciding whether their children participated in the module, without being able to really know what the children thought or would have wanted.

On the other hand, the decision to direct the program to a children's audience is based on the possibilities offered by the methodologies contemplated in the project and the experiences of the cases studied in the diagnosis, but it is also reaffirmed when considering the Theory of Cognitive Development of Jean Piaget and the stage of concrete operations, where initial rhythmic learning can be associated with logical operations such as serialization, numbering and classification that are presented at the ages considered in the respective stage.

Linked to this, a reconsideration of the strategies with which the project is promoted and presented is proposed, seeking to make it attractive to families, as well as finding means so that boys and girls can learn about the program directly. It is also considered that the promotion on networks was limited to users who were followers of the program or direct contacts, considering payment for advertising as an option within the area of opportunities.

Derived from weakness, a threat can be identified that gives rise to a new line of research: after two years of pandemic, we are returning to a "normality" in which social isolation is ruled out and where presence is prioritized again. The disinclination of families to have their children carry out online activities may be related to a fatigue with virtuality. The online modality, which during the pandemic was presented as the only way to continue with most educational activities, apparently returns to its complementary status, which opens new research questions:

- ¿What strategies and/or virtual resources do music education teachers and institutions continue to use after the pandemic?

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- ¿Have the way music teachers use new technologies for their teaching practice changed?
- ¿What lessons does the pandemic leave us in terms of adaptation and educational innovation?

Without a doubt, the experience of the pandemic shows us the need for both educators and students to be in constant training and development of our technological skills, also having an openness to changes and to try new possibilities outside the established paradigms.

At the time of closing this intervention, the Per-Q project remains active, considering expanding its reach to audiences of different ages and different contexts, such as working with special educational needs, and taking the experience of the implementation of its first course as learning to improve even more the quality of its products from the pedagogical-didactic to the technological.

The search for strategies and implementation of interventions that go hand in hand with the constant technological and social advances in this post-pandemic era is presented as the main challenge, but also as a fertile field of possibilities, for all teachers in the management of learning in virtual environments.

Authors' Contribution

Martínez-González, Fernando Eduardo: Contributed to the project idea, research method. He supports the design of the instrument and software.

Macías-Brambila, Hassem Rubén: He directed the project and contributed to the selection of the theories, as well as the design and testing of the instruments and applications for its release.

Rodríguez-Jiménez, Liza Mayela: She contributed to the validation of each of the theoretical elements, thus contributing to the triangulation of the process, in addition to defining the micro and macro environment.

López-Laguna, Ana Bertha: She contributed to the methodological validation, tool selection and validation of the design and evaluation phases of the project.

Funding

The research did not receive any funding.

Abbreviations

COVID-19	Coronavirus disease 2019
G-Suite	Google workspace
ICT	Communications and Information Technologies
IMPI	Mexican Institute or Industrial Property
Per-Q	Percussion
VLE	Virtual Learning Enviorements

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Article

Use of Kahoot, Quizizz and Educaplay as formative assessment for student learning in elementary school

Uso de Kahoot, Quizizz y Educaplay como evaluación formativa para el aprendizaje de los estudiantes en la educación primaria

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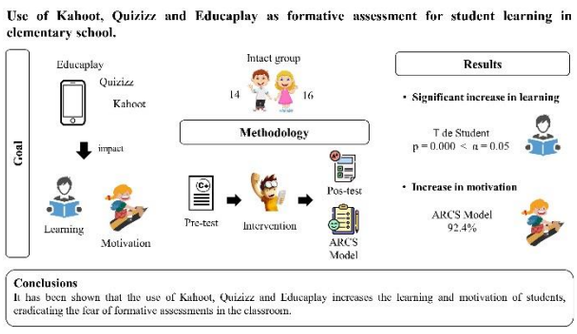
Abstract

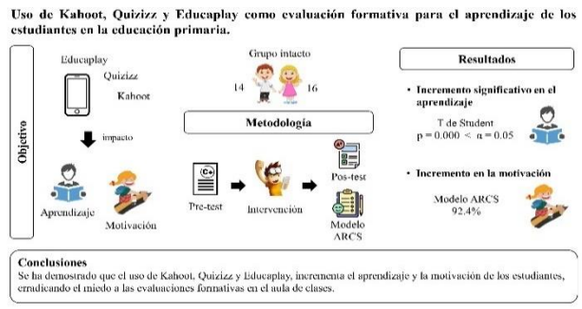
The present research was developed in an elementary school in the city of Ocosingo, Chiapas, Mexico; It focused on the use of applications such as Kahoot, Quizizz, Educaplay, internet and mobile devices, to carry out formative evaluation in the classroom and determine its impact on the learning of 4th grade students, on the topic of Mesoamerican Cultures in the subject of History. The study was carried out under a descriptive quantitative approach with a quasi-experimental design, using as data collection instruments a performance test and a questionnaire to measure students' Motivation through the ARCS Model (Attention, Relevance, Confidence and Satisfaction). The results show that the use of these applications significantly increases student learning, developing motivation to study and learn the topic addressed.



Applications; ARCS Model; Formative evaluation; Elementary school

Resumen

La presente investigación se desarrolló en una escuela primaria de la ciudad de Ocosingo, Chiapas, México; se centró en la utilización de aplicaciones como Kahoot, Quizizz, Educaplay, internet y dispositivos móviles, para realizar la evaluación formativa en el aula de clases y determinar su impacto en el aprendizaje de los estudiantes del 4º. Grado, en el tema de las Culturas Mesoamericanas de la materia de Historia. El estudio se realizó bajo un enfoque cuantitativo descriptivo con diseño cuasiexperimental, utilizando como instrumentos de recolección de datos un test de rendimiento y un cuestionario para medir la Motivación de los estudiantes a través del Modelo ARCS (Atención, Relevancia, Confianza y Satisfacción). Los resultados demuestran que la utilización de éstas aplicaciones incrementa significativamente el aprendizaje de los estudiantes, desarrollando la motivación por estudiar y aprender el tema abordado.



Aplicaciones; Modelo ARCS; Evaluación formativa; Educación primaria

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Introduction

Technology has come to revolutionise the way in which teachers are teaching and learning in the classroom; however, it has not been an easy task to adapt to these current pedagogical changes, which demand the integration of technology into the curriculum at different educational levels, especially in basic education.

Nowadays, students are digital natives, as they learn to use technology naturally, so teachers must acquire digital competences to strengthen the teaching and learning process, in order to get the attention of students, so that they acquire the knowledge and skills that are intended to be achieved in the objectives of the subjects.

This points to a scenario for a pedagogical and didactic change in teaching practice, where one must move from transmitter of knowledge to facilitator of access, selection, evaluation and transformation of the same to students, so that a competent teacher would be the one who integrates a triple focus knowledge: disciplinary, pedagogical and technological (Díaz-Arce & Loyola-Illescas, 2021).

Within this practice, it is very important to assess student learning, we can talk about the most common ones such as formative and summative assessment, in this study we will focus on the first one.

Formative assessment allows to improve student learning, for this, their performance must be evaluated (Moreno, 2016), through the activities developed, where 'the teacher identifies student errors, understands their causes and makes decisions to overcome them, improves both student learning and their teaching performance' (Pasek & Mejía, 2017, cited in Joya, 2020, p. 182); this type of evaluation is applied during the development of the thematic units, where the participation of the teacher is essential, through the monitoring of the results obtained and issuing feedback to students in each evaluation applied, allowing to establish actions to improve and achieve the learning objectives of the thematic units of the subjects (Martínez, 2011, cited in Salazar-Pastrana et al, 2014; Sánchez & Escobar, 2015).

Since the last century, Information and Communication Technologies (ICT) have made it possible to innovate the teaching and learning process with the implementation of digital didactic resources, so that it is attractive and enjoyable at all times for students; this is why teachers must seek 'different methods that promote teaching and learning in students, taking technology as a resource of vital importance, considering that students are attached to ICT from an early age' (Cevallos et al. 2019, p. 88).

Nowadays, there are several applications for formative assessment that allow to increase students' learning and motivation in different subjects (Morón et al., 2022; Arias-Becerra et al., 2022; Medina et al, 2022; Luzardo & Farías, 2021), eradicating the fear of classroom assessments, making them more motivating for students through games, such as Kahoot, Quizz, Educaplay and Socrative (Delgado & Chicaiza, 2022), provided that the teacher makes a good design, development and execution of the activities, playing a very important role in the constant feedback of the activities to generate that motivation (Prada et al., 2021; Walss, 2021).

Problem statement

Education in Mexico has a large educational backlog (3.8 million people), with Chiapas being the state that leads this statistic (REDIM, 2023).

The municipality of Ocosingo is located in the state of Chiapas, at the entrance to the Lacandon Jungle, and is one of the largest municipalities in the state; there is an enormous digital divide in this municipality, as well as in several municipalities in the state of Chiapas and in other states with similar conditions (Lezama & Orizaga, 2024), which is why technology is absent in basic education centres.

According to data from the State Coordination of Continuing Education for In-Service Teachers (2023) of the Ministry of Education of the State of Chiapas, the percentage of teachers trained in pedagogical and technological issues is low in relation to the total number of teachers at the basic level, so that, for them, educational innovation in the use of technological tools to support the teaching and learning process is something complex to assimilate and above all to contextualise.

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It is evident that primary schools do not have computer equipment, mobile devices (smartphones, tablets or laptops), internet and projectors available to teachers, to be used in the teaching and learning process as a complement to the activities set out in the free textbooks, however, these books consider as complementary material for student learning, the consultation of videos or external readings that require an internet connection and any of the aforementioned technological equipment.

It is difficult to assimilate that after a global pandemic in which the Mexican Ministry of Education's indication was to transfer face-to-face education to an emergency remote (virtual) education, there is still a lack of computers and internet, which are indispensable in primary schools for the acquisition of digital competences by students from an early age. This absence means that teachers do not have the necessary digital competences to innovate the teaching and learning process, continuing with traditionalist teaching in the classroom.

This is why the Chiapas State Government has designed strategies within the Chiapas State Development Plan 2019-2024, to eradicate school dropout at the basic level, caused by the lack of interest in attending classes or studying, leading to the poor school performance shown by students, as well as, and not least, the lack of interest in the professionalisation of teachers and the lack of innovative proposals in the teaching and learning process that increase this problem.

Objective

Based on the above, this research focused on determining the impact of the use of Kahoot, Quizizz and Educaplay as formative assessment in the learning of students in the 4th. Grade 4 students at Cuauhtémoc Primary School in Ocosingo, Chiapas, in the subject of Mesoamerican Cultures in History.

Methodology

This research was developed under a descriptive quantitative approach with a cross-sectional quasi-experimental design (Hernández-Sampieri & Mendoza, 2018).

Through two dependent groups, with the independent variable being the use of the applications Kahoot, Quizizz and Educaplay during the intervention of the study, and the dependent variables being academic performance and motivation, and therefore, the following hypotheses were established:

H1: The use of Kahoot, Quizizz and Educaplay for formative assessment in the classroom improves the learning of 4th. Grade of Cuauhtémoc Primary School.

H2: The perception of 4th. Grade of Cuauhtémoc Primary School is high in relation to the motivation for their learning with the use of Kahoot, Quizizz and Educaplay for formative assessment in the classroom.

Sample

The study sample was non-probabilistic and intentional, consisting of a group of 30 students, in which parents gave their written consent for their children to participate in the study, mentioning that the data collected would be treated confidentially and for statistical purposes; the segmentation by gender consisted of 16 girls and 14 boys, between 9 and 10 years of age.

Data collection instruments

As data collection instruments, a performance test was applied to measure the variable ‘academic performance’, designed and validated by the teachers of the 4th grade of the Cuauhtémoc Elementary School in Cuauhtémoc.

The test was made up of 25 questions to evaluate the topic of Mesoamerican cultures in the subject of History. To determine the normality of the data, the Shapiro-Wilk test was performed through the R Software Version 2023.12.0, where a value of $p = 0.0181$ was obtained for the pre-test and $p = 0.8921$ for the post-test, due to the fact that the pre-test is less than the established significance level value of $\alpha=0.05$, the data do not behave normally, as shown in graphs 1 and 2, therefore, the non-parametric Wilcoxon Signed Ranks test was applied to calculate the difference in means, which will allow us to evaluate the H1 of the research.

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Box 1

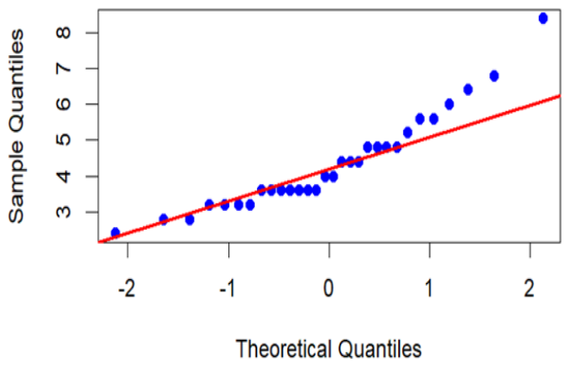

Figure 1

Pre-test quantile plot for normality of data

Source: Research data

The graph above shows that some of the data are far from the line, indicating that the data do not follow a normal distribution.

Box 2

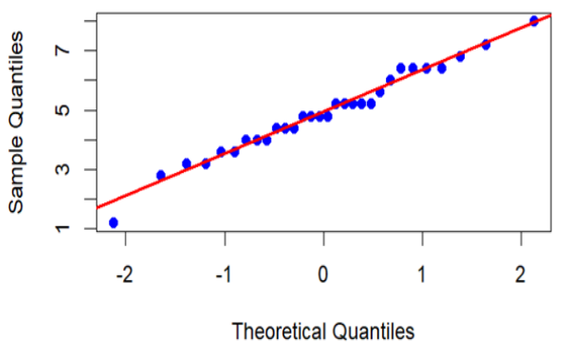

Figure 2

Post-test quantile plot for normality of data

Source: Research data

In the graph above, it can be seen that most of the data are very close to the line, indicating that the data follow a normal distribution.

On the other hand, for the variable "motivation", the questionnaire was adapted to measure Motivation through the ARCS Model (Attention, Relevance, Confidence and Satisfaction), designed and validated by Aroca-Reyes & Llorente-Cejudo (2023), the instrument consists of 3 questions in each of the dimensions mentioned as shown in Table 1.

Box 3

Table 1

Survey to measure motivation

Dimension	Ítems
Attention	**1.** Did you enjoy doing these learning activities?
	2. Do you feel happy for the effort made in these activities?
	3. Would you like to continue doing this kind of learning activities?
Relevance	**4.** ¿Habías utilizado éstas aplicaciones para realizar las actividades?
	5. ¿Te ha gustado utilizar las aplicaciones para realizar éstas actividades?
	6. ¿Te gustaría volver a utilizar las aplicaciones para aprender otros temas?
Trust	7. Were you confident in carrying out these activities using the apps?
	8. Did you learn how to use the applications when doing these activities?
	9. Would you feel confident to use these applications again another time?
Satisfaction	10. Did you maintain your attention while doing the activities with the apps?
	11. Did the use of the apps help you to stay attentive while doing the activities?
	12. Did the use of several apps help you to maintain your attention to perform the activities?

Source: Adapted from Aroca-Reyes and Llorente-Cejudo (2023, p. 153).

In order to calculate the reliability of the instrument, a pilot test was carried out with a sample of 21 4th grade students. Grade of the Marcos Villanueva López Rural Primary School, using Cronbach's alpha coefficient through the JASP Software version 0.18.1, obtaining a value of p = 0.721 located in the High magnitude range (Ruíz, 2013), being an instrument with an Acceptable reliability coefficient, since it is higher than 0.70 (Oviedo & Campo-Arias, 2005).

Box 4

Table 2

Reliability statistics

Estimate	Cronbach's α
Point estimate	0.721
95% CI lower bound	0.498
95% CI upper bound	0.860

Source: Research data

Development of the intervention

The intervention of the study in the 4th. The intervention of the study in the 4th grade of Cuauhtémoc Primary School was developed through the following phases:

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Phase 1. Presentation of the study

The researchers went to Cuauhtémoc Primary School to meet with the Headmaster, to whom the objective of the research study was explained. One teacher was interested in the study and the other two did not want to participate.

Phase 2. Authorisation of the study

The researchers submitted to the principal a consent form for the parents of the students in Grade 4, Group B, in which the parents of the students were asked to give their consent.

The researchers presented the Director with a form to give consent for their children to participate in the study by answering the instruments designed and for photographs to be taken during the intervention. Subsequently, teams of 4 students were formed to carry out the activities during the intervention.

Phase 3. Design of the games

The formative assessments were designed using the applications chosen by the researchers for the development of the intervention: Kahoot, Quizizz and Educaplay. In the first, 2 games were created with 10 multiple choice and true/false questions, establishing a time limit of 1 minute maximum for each question; in the second, 2 games were created with the same number and type of questions, as well as the same time limit established for each one of them; for the third, 4 games were designed: matching columns, crossword, memorama and froggy jumps, establishing the same number of questions and time limit for each one of them.

Box 5

Figure 3

Examples of questions designed in the Kahoot games

Source: Kahoot

Box 6

Figure 4

Examples of questions designed in Quizizz games

Source: Quizizz

Box 7

Figure 5

Examples of questions designed in Educaplay games

Source: Educaplay

Phase 4. Intervention

On the first day, the pre-test (performance test) was applied to find out the students' previous knowledge, since the teacher had already taught the topic for the development of the study. On the following days, educational games were developed to reinforce the topic, using the aforementioned applications.

Each day, the points acquired by each of the teams were recorded and medals were awarded to the first, second and third places, which moved as the games progressed; at the end, a prize was awarded to the first three places, based on the final ranking (see Figure 10).

Box 8

Figure 6

Application of the pre-test

Source: Own creation

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Box 9

Figure 7
Games developed in Kahoot
Source: Own creation

Box 10

Figure 8
Games developed in Quizizz
Source: Own creation

Box 11

Figure 9
Games developed in Educaplay
Source: Own creation

Box 12

Equipos	Puntos Juego 1 (Kahoot)	Puntos Juego 2 (Educaplay)	Puntos Juego 3 (Quizizz)	Puntos Juego 4 (Educaplay)	Puntos Juego 5 (Kahoot)	Puntos Juego 6 (Educaplay)	Puntos Juego 7 (Quizizz)	Puntos Juego 8 (Educaplay)	Total
Estrella Fugaz	3,251	0	5,790	2,000	5,958	4,000	4,440	0	23,399
Los Dinos	3,128	0	1,780	2,400	7,903	10,000	6,580	5,000	38,791
Enanitos Toreros	3,598	0	3,470	3,400	5,908	6,000	5,460	4,000	31,836
Michis	4,141	0	2,260	0	4,675	1,000	4,020	1,000	17,094
Conejitos	2,585	1,500	2,460	800	3,653	6,000	6,110	6,000	28,908
Los Capitanes	4,107	1,300	4,480	800	5,068	1,000	5,640	1,500	20,195
Pandas	835	1,400	1,710	2,000	5,308	3,000	5,230	2,500	21,983

Figure 10
Scores obtained by the teams
Source: Own creation

Box 13

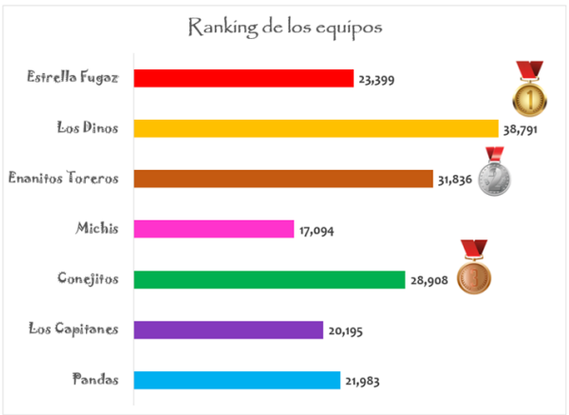

Figure 11
Final ranking after the development of all games
Source: Own creation

Phase 5. Final data collection

On the last day, the post-test (performance test) was applied to find out the learning acquired by the students through the use of these applications; then, the instrument that measured motivation was applied to find out the perception of the students in relation to the development of the designed activities.

Box 14

Figure 12
Application of the post-test
Source: Own creation

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Results

Academic performance

For the validation of the hypothesis (H1), the non-parametric Wilcoxon Signed Ranks test for dependent samples was performed, obtaining a value of p = 0.0269, which is lower than the established significance level value of α = 0. 05, therefore, it is concluded that there is a significant difference, rejecting the null hypothesis and accepting the established hypothesis of the study, in which 'The use of the applications Kahoot, Quizizz and Educaplay as formative assessment in the classroom significantly improves the learning of students in the 4th. Grade of Cuauhtémoc Primary School'.

These results are similar to those found by (Rayan & Watted, 2024), who performed a Student's t-test for independent samples, obtaining a value of p = 0. 000, demonstrating that there were significant differences in student learning when using Kahoot, likewise, the findings found by Solano & Zamalloa (2022), who used Kahoot and recommended its use to increase the academic performance of students, being this an application that provides legitimate, efficient and useful results to measure learning (Ahzim et al., 2023); as well as in the study conducted by Betancur & Robayo (2023), where they used the applications Kahoot, Quizizz, Quizalize, Educaplay and Math Game, they found that students generated significant learning in their evaluations, demonstrating that the use of these applications increases such learning in various subjects.

On the other hand, the comparison of results between girls and boys was carried out, first performing the Shapiro-Wilk normality test of the data with the Software R Version 2023.12.0, where a value of p = 0.2534 was obtained for the academic performance of the girls and p = 0. 6550 for boys, indicating that in both cases the data behave normally, so Student's t-test for dependent samples was applied, obtaining a value of p = 0.2182, which is greater than the established significance value of α = 0.05, therefore, there is no significant difference in academic performance between the two sexes.

Motivation

The results obtained from the study are addressed for each of the dimensions of the ARCS Model: Attention, Relevance, Confidence and Satisfaction based on the instrument applied, establishing the following rating scale (Table 3) on the perception of the students, in relation to the relative frequency obtained in the statements of each question.

Box 15

Table 3

Rating scale

Rating	**Perception %**
Very low	[0 , 20]
Low	(20 , 40]
Medium	(40 , 60]
High	(60 , 80]
Very high	(80 , 100]

Source: Own creation

Dimension Attention

Box 16

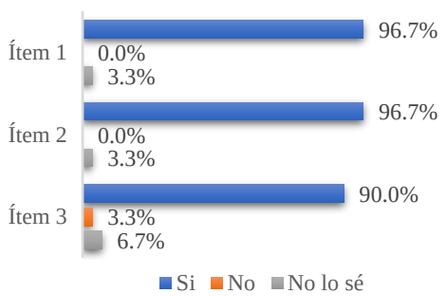

Figura 13

Results of the Attention dimension

Source: Research data

The perception obtained by the students presents a very high level in each item of the Attention dimension, since in Figure 13 it is observed that the vast majority of students said "Yes" in each item, managing to stimulate the curiosity and interests of students within the intrinsic motivation (Keller, 2010), due to the design of activities based on gamification through the use of these applications.

In Table 4, we observe the results segmented by gender, most of the girls and boys answered the option "Yes", presenting a very high level of perception in this dimension.

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Box 17

Table 4

Gender perception in the Attention dimension

Ítem	Sí		No		No lo sé	
	F	M	F	M	F	M
1	16 100%	13 92.9%	0 0%	0 0%	0 0%	1 7.1%
2	15 93.8%	14 100%	0 0%	0 0%	1 6.3%	0 0%
3	15 93.8%	12 85.7%	0 0%	1 7.1%	1 6.3%	1 7.1%

Source: Own creation

Dimension Relevance

Box 18

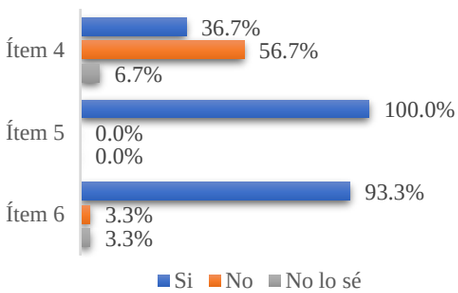

Figure 14

Results of the Relevance dimension

Source: Research data

In Figure 14, it can be seen that the perception obtained by the students in item 4 presents a Medium level, although it can be seen as a negative result for having answered "No", however, it means that most of the students had not used these applications to learn the subject, confirming the lack of technological infrastructure equipment, since they lack accessibility to these and especially internet service (INNE, 2019). In items 5 and 6, the students' perception has a Very high level, indicating that the designed activities are relevant, feeling motivated to learn the topic addressed during the intervention (Keller, 2010).

In Table 5, we observe the results segmented by gender; in item 4, most of the girls answered the option "No", while half of the boys answered that they had already used these applications; on the other hand, most of the girls and boys answered the option "Yes" in items 5 and 6, presenting a very high level of perception (Keller, 2010).

Box 19

Table 5

Perception by gender in the Relevance dimension

Ítem	Yes		No		I don't know	
	F	M	F	M	F	M
4	4 25%	7 50%	11 68.8%	6 42.9%	1 6.3%	1 7.1%
5	16 100%	14 100%	0 0%	0 0%	0 0%	0 0%
6	15 93.8%	13 92.9%	0 0%	1 7.1%	1 6.3%	0 0%

Source: Own creation

Confidence Dimension

Box 20

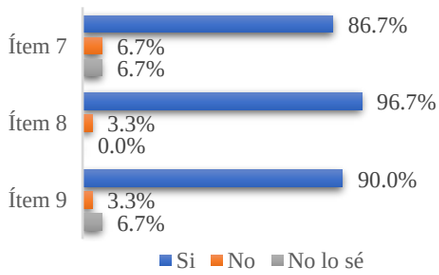

Figure 15

Results of the Confidence dimension

Source: Research data

Figure 15 shows that the perception obtained by students shows a very high level in each item of the Confidence dimension, since the vast majority of students said “Yes” in each item, indicating that they are motivated to learn the subject and are convinced that they will succeed in their learning. (Keller, 2010).

In Table 6, we observe the results segmented by sex, most of the girls and boys answered the option “Yes” in each item, presenting a very high level of perception in this dimension. It is noteworthy that in item 8 all the girls learned to use these applications during the development of the activities.

Box 21

Tabla 6

Perception by gender in the Trust dimension

Ítem	Yes		No		I don't know	
	F	M	F	M	F	M
7	13 81.3%	13 92.9%	1 6.3%	1 7.1%	2 12.5%	0 0%
8	16 100%	13 92.9%	0 0%	1 7.1%	0 0%	0 0%
9	14 87.5%	13 92.9%	0 0%	1 7.1%	2 12.5%	0 0%

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Dimension: Satisfaction

Box 22

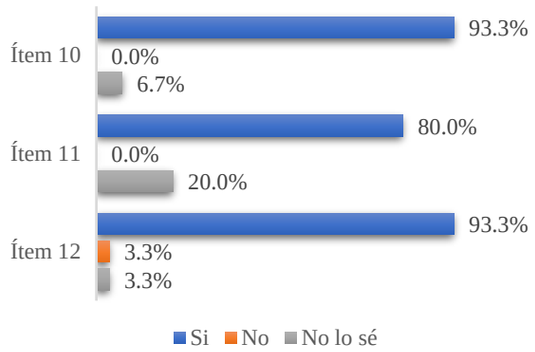

Figure 16

Results of the Satisfaction dimension

Source: Research data

The perception obtained by the students presents a very high level in each item of the Satisfaction dimension, since in figure 16 it can be seen that the vast majority of the students answered "Yes" in each item, showing that the students have managed to motivate themselves to learn the subject during the development of the activities, stimulating satisfaction by achieving better grades as part of extrinsic motivation (Keller, 2010).

In Table 7, we observe the results segmented by gender, most of the girls and boys answered the option "Yes" in each item, presenting a very high level of perception in this dimension. It is noteworthy that in item 10 all the girls maintained their attention during the development of the activities when using these applications.

Box 23

Table 7

Gender perception in the Satisfaction dimension

Ítem	Yes		No		I don't know	
	F	M	F	M	F	M
10	16 100%	12 85.7%	0 0%	0 0%	0 0%	2 14.3%
11	13 81.3%	11 78.6%	0 0%	0 0%	3 18.8%	3 21.4%
12	15 93.8%	13 92.9%	0 0%	1 7.1%	1 6.3%	0 0%

Source: Own creation

Based on the results obtained, it is shown that 92.4% of the students present a very high level of motivation in learning the subject, using Kahoot, Quizizz and Educaplay, therefore, the null hypothesis is accepted, because the expectations in relation to motivation were exceeded, and the established hypothesis (H2) 'The perception of the students of the 4th. Grade of Cuauhtémoc Primary School is high in relation to the motivation for learning with the use of the applications Kahoot, Quizizz and Educaplay as formative assessment in the classroom'.

The results obtained are similar to the study conducted by Huaman (2021), where 91% of the opinions expressed by the students mentioned that they would always and almost always be motivated to learn with the use of Kahoot, due to the fact that it is a visually attractive and easy to use application (Firdiansyah & Pamungkas, 2021, cited in Ahzim et al. , 2023, p. 56).

On the other hand, the use of Quizizz also motivates students to learn, in the study conducted by Romadhon et al. (2023), the students surveyed mentioned that this application motivated them because while learning, they played and competed with their other classmates to achieve higher scores. Likewise, in the study conducted by Dias et al. (2022), they found that the Educaplay platform, in addition to motivating students, develops other skills such as the development of their critical and argumentative capacity, as well as the values of respect towards their classmates and collaborative work.

Conclusions

Creating a technology-mediated learning environment is not an easy task, even more so when teachers lack the digital competences to carry them out. The present study has shown that introducing technologies in the classroom increases student learning; applications such as Kahoot, Quizizz and Educaplay are ideal for eradicating the fear of traditional formative assessments that are still used, such as written exams.

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The applications used awaken motivation in students to learn any subject that is addressed with them, because competition is generated between them, which makes them motivated to study, generating interest and enthusiasm to get better scores to excel in the final scores in each game, thus creating a fun learning environment for them, being a natural at that age; therefore, what better to use these applications from an early age, as it has been shown in other studies, the generation of other skills such as critical analysis, reflective and argumentative to avoid making mistakes in the answers.

Based on the favourable results achieved in this study, state and federal education authorities in Mexico, and why not in other countries, are urged to invest in technological infrastructure for classrooms in basic level schools, in order to generate digital competencies in students from the first grades of their educational training, As well as to implement a teacher training programme in which teachers acquire digital competences, allowing them to generate learning environments where technology is included, in order to improve and develop meaningful learning in students, as well as to acquire other skills and values that complement their academic training.

Some open lines for the future that this research leaves open are to study the critical and reflective analysis of students in the use of these applications, in a context where there is a lack of technological devices such as the internet and computers in the classroom, especially in rural schools in various states of the Mexican Republic; the perception generated in teachers by the introduction of these applications in their daily practice; and the generation of reading skills in students using these applications from an early age.

Declarations

Conflict of interest

The authors declare no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Authors' contributions

Domínguez-Gutú, Jesús: contributed with the idea of the project; the methodological approach, scope and design of the research; the design of the activities in the applications; adaptation of the instruments; systematisation and statistical analysis of the results; and writing of the article.

Trejo-Trejo, Gilberto Abelino: contributed to the adaptation of the instruments; application of the instruments; systematisation and statistical analysis of the data; and drafting of the article.

Gordillo-Espinoza, Emmanuel: contributed to the systematisation of the background for the state of the art; the design of the activities in the applications and revision of the article.

Constantino-González, Fernando Exiquio: contributed to the application of the instruments; systematisation of the data and revision of the article.

Availability of data and materials

The Cuauhtémoc Primary School provided the classroom, furniture and multimedia equipment for the development of the study intervention.

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Abbreviations

ARCS	Attention, Relevance, Trust and Satisfaction
INNE	National Institute for the Evaluation of Education
REDIM	Network for Children's Rights in Mexico
TIC	Information and Communication Technologies

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Background

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Article

Educational Lag in Higher Secondary Education Institutions in Ixtapaluca, Valle de Chalco and Chalco

Rezago educativo en las Instituciones de Educación Media Superior en Ixtapaluca, Valle de Chalco y Chalco

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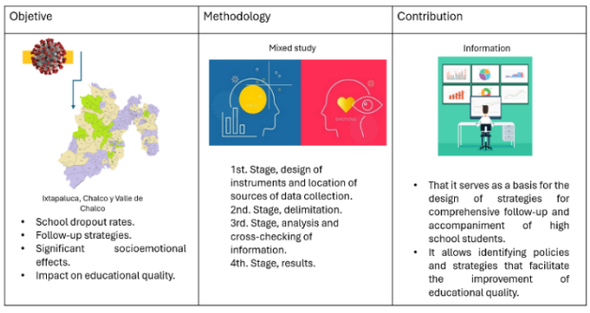
* ✉ [mx]

Abstract

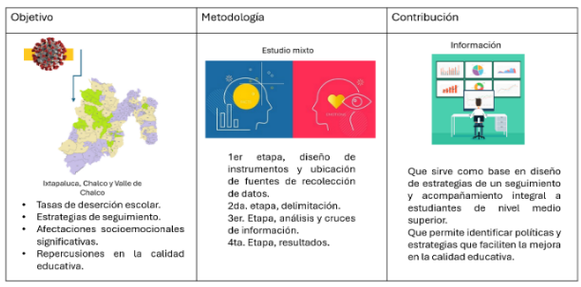
Objective: The study entitled "Educational Lag in Higher Secondary Education Institutions in Ixtapaluca, Valle de Chalco, and Chalco" is to analyze the impact of the COVID-19 pandemic on school dropout rates and educational quality in these municipalities. *Methodology:* The research uses a mixed-methods approach, combining quantitative and qualitative data. Data collection included surveys, interviews with school principals, and focus groups with students and teachers. This methodology allows for a comprehensive analysis of dropout rates and educational quality, considering both statistical data and personal experiences of those affected by the pandemic. *Contribution*: The findings of this study are expected to provide valuable insights into the specific challenges faced by upper secondary education institutions in the target municipalities. The research will inform the development of effective strategies to address educational lag, improve retention rates, and enhance the overall quality of education. It aims to benefit policymakers, educators, and the student community by providing evidence-based recommendations to mitigate the adverse effects of the pandemic on education. The study highlights the importance of tailored interventions and support systems to help students address the challenges posed by the COVID-19 pandemic and ensure a more resilient and inclusive educational environment in the future.



Educational lag, School dropout, Educational quality

Resumen

Objetivo: El estudio titulado "Rezago educativo en las Instituciones de Educación Media Superior en Ixtapaluca, Valle de Chalco y Chalco" tiene como objetivo analizar el impacto de la pandemia de COVID-19 en las tasas de deserción escolar y la calidad educativa en estos municipios. *Metodología*: La investigación utiliza un enfoque de métodos mixtos, combinando datos cuantitativos y cualitativos. La recopilación de datos incluyó encuestas, entrevistas con directores de escuelas y grupos focales con estudiantes y docentes. Esta metodología permite un análisis integral de las tasas de deserción y la calidad educativa, considerando tanto los datos estadísticos como las experiencias personales de los afectados por la pandemia. *Contribución*: Se espera que los hallazgos de este estudio proporcionen información valiosa sobre los desafíos específicos que enfrentan las instituciones de educación media superior en los municipios objetivo. La investigación informará el desarrollo de estrategias efectivas para abordar el rezago educativo, mejorar las tasas de retención y mejorar la calidad general de la educación. Tiene como objetivo beneficiar a los responsables de políticas, educadores y la comunidad estudiantil al ofrecer recomendaciones basadas en evidencia para mitigar los efectos adversos de la pandemia en la educación. El estudio destaca la importancia de intervenciones y sistemas de apoyo personalizados para ayudar a los estudiantes a enfrentar los desafíos planteados por la pandemia de COVID-19 y garantizar un entorno educativo más resiliente e inclusivo en el futuro.



Rezago educativo, Deserción escolar, Calidad educativa

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Introduction

The research 'Educational backwardness in Higher Secondary Education Institutions in Ixtapaluca, Valle de Chalco and Chalco' arises from the need to identify the current demands of young people after the pandemic in the academic sphere.

The isolation due to the COVID-19 contingency in Mexico was extended from 23 March 2020 to 10 October 2022, aggravating an already existing educational problem and making even more evident the polarisation of education in Mexico, as well as having a significant impact on the mental health of students, the uncertainty of this situation increased the insecurity of young people, as well as that of their teachers and school authorities.

After the isolation, staggered schedules were adopted adopting a mixed modality, where part of the students stayed at home and another part attended the educational institution in person, however, the concern about feeling vulnerable was evident, (Roy et al, 2024) mentions how factors such as the perception of safety, effectiveness of the vaccine and the quality of communication influenced the decision of the students to receive the vaccine, placing 69.9%, the level of acceptance of the vaccine in the students.

The level of acceptance of the vaccine was 69.9%, although despite this, concerns about side effects and effectiveness persisted. However, as time went on, there was more certainty and confidence in adopting the hybrid model. In this context, emotional challenges were a determining factor in adopting appropriate strategies:

'For their part, more than a third of students (37%) say they were able to cope successfully with the emotional challenges posed by the pandemic, but equally, more than a third (36%) report not agreeing that they were able to cope with these challenges. More than half of the students (56%) have maintained positive thoughts in the face of the adversity experienced during the contingency, and only 26% say they are affected by the news circulating on this issue in the media'. (Medina Gual, et al., 2021, p. 136).

According to (INEGI, 2021, p. 1).

- 33.6 million people between the ages of 3 and 29 were enrolled in the 2019 - 2020 school cycle (62.0% of the total). Of these, 740,000 (2.2%) did not complete the school cycle: 58.9% for some reason associated with COVID-19 and 8.9% for lack of money or resources.
- 'For the 2020-2021 school cycle, 32.9 million (60.6% of the population aged 3-29) were enrolled.'
- 'For reasons associated with COVID-19 or for lack of money or resources, 5.2 million people (9.6% of the total 3-29 year-olds) did not enrol for the 2020-2021 school year.'

Meanwhile, interviews conducted with directors of Secondary Education Institutions (IEMS) in the eastern zone revealed worrying data, they mentioned having a dropout rate of 70% in the third year of baccalaureate and a decrease of 30% in the entry to the first grade.

They highlighted the lack of retention mechanisms in the institutions for students who left the synchronous virtual classes, and many of them opted to enter the labour market.

This context motivated the research project on the impact of the pandemic on the IEMS in the Eastern zone of the State of Mexico.

The research uses a mixed methods approach, combining quantitative and qualitative data, through interdisciplinary work with documentary research axes. Data collection included 3 interviews with school principals, 4 focus groups with students and 1 focus group with teachers. This methodology allows for a comprehensive analysis of dropout rates and educational quality, considering both statistical data and the personal experiences of those affected by the pandemic. The research proposes to examine in depth the impact of dropout on at least three generational cohorts, analysing existing retention and recapture strategies.

This analysis is essential to develop targeted interventions and educational policies that can mitigate the impact of educational backwardness and promote a sustainable recovery in the quality and accessibility of upper secondary education in the region.

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Study problem

The COVID-19 pandemic caused a high dropout rate at the upper secondary education level in the municipalities of Chalco, Valle de Chalco and Ixtapaluca in the 2019-2020 school year. By 2021, their terminal efficiency was reduced and the number of secondary level students entering the Institutions of Higher Secondary Education (IEMS) was also lower, which suggests that the recovery of enrolment and terminal efficiency of these schools will be in the medium term, and will require strategies for attracting, retaining and levelling students by the management and educational staff of their schools.

This situation is critical not only because of its immediate effects on the affected students and educational institutions, but also because of its long-term implications for the social and economic fabric of these municipalities.

Therefore, the research questions that give rise to this study are as follows:

- How has the dropout rate evolved in the IEMS of Chalco, Valle de Chalco and Ixtapaluca before, during and after the COVID-19 pandemic, and what socio-economic, academic and contextual factors have influenced these variations?
- What follow-up and accompaniment strategies have the IEMS in the region implemented to prevent and address school dropout cases during and after the pandemic, and how effective have they been in reducing dropout rates?
- What are the most significant socio-emotional impacts experienced by students at IEMS in the region as a result of the COVID-19 pandemic?
- How was the educational quality of students at the upper secondary level affected during the pandemic?

Objectives

General Objective

To evaluate the impact of the COVID-19 pandemic on dropout levels in the IEMS of the municipalities of Chalco, Valle de Chalco and Ixtapaluca, analysing the institutional mechanisms for monitoring dropout, the socio-emotional effects on students and the effect on the quality of education.

Specific objectives

- To analyse school dropout levels in the IEMS of Chalco, Valle de Chalco and Ixtapaluca before, during and after the COVID-19 pandemic, identifying variations and trends at different educational levels.
- Examine the institutional mechanisms implemented by the IEMS to follow up on school dropout cases during and after the pandemic, assessing their effectiveness and scope.
- To assess the socio-emotional effects of the pandemic on students at the IEMS in the region under study.
- To analyse the impact on the educational quality of students in the context of the pandemic.

Methodological framework

The research arises from the need to identify the current demands of young people after the pandemic in the academic sphere. Isolation due to the COVID-19 contingency in Mexico lasted from 23 March 2020 to 10 October 2022.

Although there was already a serious educational problem and a gap that polarised education was recognised, this situation highlighted and aggravated this scenario, extending further and impacting the mental health of students.

As a result of some dialogues carried out with various IEMS directors in the eastern zone of the State of Mexico, which encompasses the municipalities of Ixtapaluca, Valle Chalco and Chalco, statements were compiled that gave shape to the intention to investigate more about the impacts of the pandemic, namely:

- It was noted that the dropout rate in the third year of baccalaureate reached a worrying 70%.
- Some institutions reported a 30% drop in first grade entry compared to the previous year.
- The absence of clear retention mechanisms in upper secondary institutions for those students who stopped participating in synchronous virtual classes was highlighted.

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- It was noted that most of the students who dropped out of synchronous classes made the decision to enter the labour market.

This project has had a duration of three years and has worked with an interdisciplinary team according to three research axes:

- Documentary and data processing;
- Educational research;
- Processes and dynamics of educational retention.

These research axes have been managed in their research productivity in a diachronic way and by annual stages that can be identified as follows:

First stage (2022). In this stage, the design of instruments and location of sources of information collection that would be necessary for each axis, as well as their different instruments, was begun. This was a stage of design and validation of different data collection instruments. Both in terms of statistical documentation and methodological design of data collection, it was necessary to contemplate various instruments such as:

1. A matrix for the collection of data, such as enrolment, graduation, leaving and averages by generational cohort of the selected IEMS.
2. A questionnaire for conducting interviews with directors.
3. A script for conducting student groups.
4. A script for the application of focus groups with teachers.

Second stage (2023). The delimitation involved comparatively segmenting generational cohorts, before, during and after the confinement due to the pandemic. Since the confinement implied a rupture in the school dynamics linked to the economic dynamics of the students' household units, a significant break point for school dropout was located.

The IEMS that were selected provided information segmented longitudinal cohorts over time to analyse their behaviour before and after the pandemic, corresponding to the school cycles of:

1. 2016-2019 Pre-confinement.
2. 2017-2020 With effects on terminal efficiency in the third year of baccalaureate.
3. 2018-2021 With effects on dropout, terminal efficiency of baccalaureate.
4. 2019-2022 With effects on entrance percentage in first year of baccalaureate, dropout and terminal efficiency.
5. 2020-2023 With effects on all indicators, which we could call post-confinement.

At this stage, data were collected according to the case studies, through an Excel matrix. It should be noted that we are still working on a cross-sectional comparative analysis of enrolment behaviour between the different IEMS, so this study only presents 4 of the 8 cases that are only the subject of this study. Similarly, other data collection instruments were applied: two in-depth interviews with high school directors and/or officials, meetings with two zone supervisors, three directors and two deputy directors, as well as the collection of qualitative information with young people through four focus groups, in addition to the application of a focus group with teachers.

In addition to this, three working days were held with the IEMS, two in the TUVCH and one more in the zone supervision of the general baccalaureate schools, through which teachers, counsellors, liaisons, vice-directors and directors shared their experiences of their educational centres,

The IEMS located in Ixtapaluca, Chalco and Valle de Chalco participated, with an average of 75 teachers, counsellors and administrative authorities on the first day, 30 people on the second day and 200 teachers, counsellors and administrative authorities from the area on the last day.

Third stage (2024). We are currently in this stage, carrying out the analysis and cross-checking of information between the different instruments in order to understand and explain the dropout in the different generational cohorts, the relationships between the different case studies and, to elaborate a series of recommendations from the general, academic and academic management, to the IEMS of the eastern zone of the State of Mexico.

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In sum, with these three stages, the research is approached with a mixed methodology in which both quantitative and qualitative data are considered. In this sense, a comparative analysis between institutions is considered in order to review the dropout variables in IEMS in the regions of Ixtapaluca, Chalco and Valle de Chalco, as well as to detect aspects such as dropout and retention, academic follow-up, teaching and learning practices and educational quality.

Epistemic frame of reference

The research aims to work under a systemic approach to complex problems, which identifies the cut-off from a territorial delimitation of units of analysis that share the same dynamics of exclusion, demographic characteristics, profiles of higher secondary education institutions, linked to the economic activity of the students and the educational offer at the baccalaureate level.

We assume that the entry of students at each level of education (primary, secondary, baccalaureate and higher education) has a cascading effect that depends on the immediate previous level of education. As he conceives, in complex systems, each part is interrelated with the whole, which means that the behaviour of students at different educational levels cannot be analysed in isolation, but rather in terms of their interaction with various factors.

The recovery of enrolment at the various levels of education with respect to dropout has a structural effect at baccalaureate level that depends on the recovery of previous levels, and on at least four factors related to the following units of analysis:

1. The territorial delimitation, Chalco, Valle de Chalco and Ixtapaluca, municipalities that share similar exclusion indicators and similar urban, educational and youth dynamics;

2. Educational quality indicators such as PISA and PLANEA, diagnostic exams such as EXCOBA (Entrance exam applied at the Tecnológico Universitario del Valle de Chalco -TUVCH) and COMIPEMS (Entrance exam applied to upper secondary level students).

3. The experiences of directors and/or authorities, teachers and the young people themselves in their academic trajectories.

Given these units of analysis, the construction of a common epistemic framework is required in order to work on the basis of the same reading of the complex problem to be analysed.

Frame of reference: Description of the Case Studies

The research on educational backwardness in Higher Secondary Education Institutions (IEMS) in the municipalities of Chalco, Valle de Chalco and Ixtapaluca, following the COVID-19 pandemic.

The research initially contemplated working with a sample, however, difficulties arose with data collection, as many of the institutions visited did not have the information and others did not have the confidence or willingness to collaborate with the study. For this reason, it was decided to work by case studies; selecting IEMS covering the three municipalities of Ixtapaluca, Chalco and Valle de Calco.

These cases were chosen considering their relevance and geographical location, in addition to the fact that these institutions showed interest in the study and provided the information for this research.

These case studies allow for a better understanding of the challenges faced by the aforementioned municipalities belonging to the State of Mexico. This study presents partial results by looking at only four of the eight case studies contemplated for this research. Below are four of them, representing the three municipalities contemplated in this research, as part of the partial advances of this study.

I) Case study - School 1

This school, located in San Francisco Cuautla, Ixtapaluca in a context where customs are rooted in the community, has involved adapting school dates to the customs of the place (patron saint festivals, fairs and processions, for example).

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The educational institution is a socially organised school with a small population and a single shift.

The school population reported difficulties in maintaining the motivation of the students during the confinement, as they were hard hit by the pandemic and suffered the loss of family members and neighbours.

In addition, a drop in income was reported, compared to the levels of previous generational cohorts. (See table 1).

Box 1

Table 1

Data analysed from Case Study 1

Generational cohort	Students by generational cohort	COMIPEMS Reports
2016 – 2019	118	No data
2017 – 2020	243	61
2018 – 2021	160	59
2019 – 2022	133	55
2020 – 2023	123	59

Source: Own elaboration (2023). Confidential information provided by School 1 authorities.

II) Case study - School 2

Located in Chalco, this campus faced the pandemic requiring a rapid transition to online education, which presented challenges for both students and teachers in terms of internet access and digital competencies. As in the previous case, a decline in the generational cohort is reported. (See table 2 below)

Box 2

Table 2

Data analysed from Case Study 2

Generational cohort	Students by generational cohort	COMIPEMS Reports
2016 - 2019	63	There is a consolidated COMIPEMS score per year, however, there is no correspondence of COMIPEMS reports per student..
2017 – 2020	68	
2018 - 2021	41	
2019 - 2022	65	
2020 - 2023	61 (first year only)	

Source: Own elaboration (2024). Confidential information provided by the authorities of the schools presented in the study

III) Case study - School 3

Located in Valle de Chalco, this small to medium-sized single-shift school faces several problems due to its economic and social context. Students lack sufficient technological resources and adequate conditions necessary for optimal academic development. These difficulties were exacerbated by the isolation caused by the COVID-19 pandemic (see table 3).

Box 3

Table 3

Data analysed from Case Study 3

Generational cohort	Students by generational cohort	COMIPEMS Reports
2016 - 2019	145	Not provided by EMI
2017 – 2020	157	Not provided by EMI
2018 - 2021	122	Not provided by EMI
2019 - 2022	139	Not provided by EMI
2020 - 2023	141 (solo primer año)	Not provided by EMI

Source: Own elaboration (2022). Confidential information provided by School 3 authorities.

IV) Case study - School 4

The school has a low enrolment. It is located in Cerro del Tejolote, Ixtapaluca, in a context where the economic needs of the students meant great challenges, due to the socio-demographic situation in which it is located, as it is a marginalised area with problems in the social fabric resulting from high levels of insecurity. (See table 4).

Box 4

Table 4

Data analysed from Case Study 4

Generational cohort	Students by generational cohort	COMIPEMS Reports
2016 - 2019	31	Not provided by EMI
2017 – 2020	17	Not provided by EMI
2018 - 2021	23	Not provided by EMI
2019 - 2022	26	Not provided by EMI
2020 - 2023	22	Not provided by EMI

Source: Own elaboration (2023). Confidential information provided by School 3 authorities

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In the eastern region of the State of Mexico, IEMS faced unprecedented challenges that tested their capacity for adaptation and resilience.

The selection of these four case studies in the municipalities of Chalco, Valle de Chalco and Ixtapaluca, reported so far, provides a detailed overview of how these institutions managed the transition to distance learning modalities, facing challenges such as dropout, lack of technological resources and socio-economic barriers that aggravated existing inequalities among students.

These cases not only reflect the unique difficulties of each locality, but also highlight the strategies implemented to continue education under extremely difficult circumstances.

Reflecting on these experiences is essential to understand not only the immediate impact of the pandemic on education, but also to project lessons learned into the future of the education sector.

It is crucial to assess the effectiveness of responses and the sustainability of emerging educational innovations.

In addition, considering these experiences allows for the identification of areas of vulnerability and strength within the education system, facilitating the development of more robust and equitable policies that can sustain education in times of crisis.

As mentioned, education is a fundamental pillar for economic development, as it provides the essential human resources to drive a country's growth, so it is necessary to implement effective policies that address disparities in access to quality education and promote greater educational equity.

This analysis contributes not only to a better understanding of the current educational landscape, but also paves the way for strengthening the resilience and adaptability of institutions in the face of future global challenges. (See table 5, concentrated case studies).

Box 5

Table 5

Concentrated case studies presented as partial results

Case Study	Location	Reflection on the Case	Important Considerations
School 1	San Francisco Acuautla, Ixtapaluca	The adaptation of school dates to local customs shows the need for flexibility in educational planning.	It is important to consider the uses and customs of the community in which the school is located and to match academic activities in order to generate greater student participation.
School 2	Chalco	The rapid transition to online education highlighted the lack of digital skills.	It is necessary to invest in digital training for students and teachers to better adapt to online learning.
School 3	Valle de Chalco	Isolation during the pandemic added emotional and academic challenges in a community with pre-existing problems.	Develop emotional and academic support programmes that respond to the specific needs of the community.
School 4	Cerro del Tejolote, Ixtapaluca	Students' economic hardship affected their participation and continuity in education.	Implement scholarship and financial support programmes for students at risk.

Source: Own elaboration. (2024).

The COVID-19 pandemic triggered a global crisis that affected all aspects of daily life, with education being one of the most impacted sectors. In the eastern region of the State of Mexico, IEMS faced major challenges that tested their capacity to adapt and resilience. The selection of eight case studies in the municipalities of Chalco, Valle de Chalco and Ixtapaluca details how institutions managed the transition to distance learning modalities, facing challenges such as dropout, lack of technological resources and socio-economic barriers that aggravated inequalities among students.

These cases not only reflect the difficulties of each locality, but also highlight the strategies implemented to continue education under complex circumstances.

Interviews and focus groups conducted with teachers and students in these institutions show testimonies of the stress and anxiety of the transition to online education, the lack of access to adequate technological devices and reliable internet connection.

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In addition, an urgent need for emotional and psychological support was identified for students who faced personal and family losses due to the pandemic. According to the study, self-esteem has a significant negative effect on anxiety, suggesting that higher levels of self-esteem may contribute to reduced anxiety in students.

Furthermore, self-esteem is also positively correlated with academic self-efficacy, implying that higher self-esteem may increase students' perception of their ability to succeed in their studies.

Teachers also expressed the need for more training in digital tools and distance learning methodologies. It is necessary to reflect on these experiences in order to understand not only the immediate impact of the pandemic on education, but also to project lessons learned into the future of the educational context. In this sense, it is essential to evaluate the effectiveness of the responses and the sustainability of emerging educational innovations.

Results

Case Study School 1

School 1, a general high school located in San Francisco Acuautla, Ixtapaluca, has faced considerable challenges during the COVID-19 pandemic. The research conducted analyses several key aspects that impacted the institution and the student community (see Figure 1).

The results are presented below in three main areas: attrition and retention, academic monitoring and teaching-learning practices, and educational quality.

a. Attrition and retention:

The institution faced a high dropout rate during the pandemic. Lack of motivation and financial difficulties were the main reasons mentioned by the students who participated in the focus group.

The school implemented emotional support programmes and personalised tutoring to try to retain students, but with limited success. (See Figure 3).

In this EMI, the pandemic had a significant impact on school dropout, with a total dropout rate of 41.52% in 2016 and an increase in the following years, with a lower percentage observed in the 2020-2023 generational cohort. Generational cohorts show variability in attrition rates, with a significant impact on retention during the pandemic. (See figure 2).

Some of these strategies were:

- Constant communication: Counsellors maintained regular contact with students and their families, using phone calls, Whatsapp messages and social media to offer support and follow-up.
- Administrative flexibility: Adjustments were made to administrative processes, such as the extension of extensions for the collection of extraordinary fees and even their omission in exceptional cases, flexibility in the enrolment process, all of this to be more empathetic to the difficulties of students.
- Emotional support: The counsellors provided emotional support to students and parents, helping to maintain motivation and commitment to education.
- According to the school principal, these strategies reduced dropout and motivated her students, although not all dropouts returned to the school when the situation began to normalise.

b. Academic monitoring and Teaching and Learning practices:

Academic follow-up during the pandemic was mainly based on the use of digital technologies and adapting teaching methods for the virtual modality. Students reported that communication with their teachers was done through platforms such as WhatsApp, Facebook, and Classroom.

This modality allowed for some flexibility, but also presented significant challenges. Despite follow-up, the online classes failed to capture the interest of all students, reporting many difficulties in keeping up with the pace of the virtual classes.

While teachers also faced significant challenges in adapting to new technologies and teaching methods.

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Teaching practices:

- Use of digital platforms: classes and activities were conducted using applications such as Classroom, Meet and WhatsApp. This allowed students to submit assignments and receive feedback, although connectivity and access to devices were recurrent problems.
- Flexibility in submitting assignments: Students were able to submit assignments in a flexible manner, which allowed them to combine their academic responsibilities with other activities, such as work.
- WhatsApp groups: WhatsApp groups with tutors and counsellors facilitated communication and monitoring of academic activities, helping to maintain an open channel for doubts and problems.

c. Educational quality:

Educational quality in the institution declined considerably during the pandemic. Post-pandemic academic evaluations revealed a drop in performance in several subjects, mainly in mathematics,

Spanish and English, highlighting the need for specific interventions to recover the previous educational level.

Educational quality has been a constant concern, with exit rates reflecting efforts to maintain educational standards. The overall completion rate was 57.62% in 2016, with variations in subsequent years due to the challenges presented by the pandemic.

Although overall average grades increased during the period of virtual education, this did not reflect students' true learning and understanding of the subjects.

The flexibility and facilities offered during the pandemic resulted in higher grades than were usually reported.

Some data on academic results are presented below:

- Grade point averages: Semester averages showed an increase during the pandemic, with values ranging from 7.4 to 7.6, depending on the semester and generation.
- Exam performance: Many students reported that their grades did not reflect their true knowledge and skills. In post-pandemic diagnostic tests, students were found to lack basic competencies in key areas such as mathematics and reading comprehension.
- Differences in modalities: There was a general preference for face-to-face classes, where students felt more involved and had a better understanding of the topics. Face-to-face interaction with teachers and peers was seen as essential for effective learning.

In sum, the results of the research in School 1 reveal the profound challenges and adaptations experienced during the COVID-19 pandemic. Retention strategies and emotional support were crucial to keep students connected to their education, although the quality of education was affected by the virtual modality and the lack of preparedness to deal with such an abrupt change.

The lessons learnt from this study will be fundamental to strengthening the resilience of the HEI in the face of future crises.

Case Study School 2

Research on the educational backlog at Escuela 2, a technological baccalaureate institution (see Figure 1), located in Chalco has revealed different challenges and responses during the COVID-19 pandemic, focusing on student attrition and retention, academic monitoring and teaching-learning practices, and educational quality.

a. Attrition and retention:

The pandemic evidenced dropout in this institution, with a notable increase in the number of students dropping out due to economic problems and lack of access to technological resources. Before the pandemic, the dropout rate was already significant, but during and after the confinement, the numbers skyrocketed.

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The school implemented several strategies to retain students, such as the provision of internet data packs and the loan of electronic devices, but these measures were not enough to fully mitigate the impact. Interviews and focus groups revealed that many students felt overwhelmed by the workload and lack of adequate support, leading some to consider dropping out of their studies.

However, the institution implemented several strategies to mitigate these problems, including the use of digital platforms to maintain communication and academic follow-up. These measures helped some students to feel accompanied and supported, although not all experienced the same level of satisfaction. (See figure 2).

The institution faced significant challenges in terms of dropout during and after the pandemic.

Prior to the pandemic, the institution already faced challenges in student retention. In 2016, the total attrition rate was 41.52%, with an increase in male attrition (44.77%) compared to female attrition (37.25%). During the pandemic, these challenges intensified, highlighting the need for more effective strategies to retain students and prevent dropout.

Dropout was mainly attributed to failure and the lack of technological resources needed to follow online classes. The pandemic highlighted these difficulties, making the digital divide and the lack of adequate support for students in vulnerable contexts even more visible.

b. Academic monitoring and Teaching and Learning practices:

During the pandemic, teaching practices moved rapidly to the online format. However, many teachers and students faced technical and adaptation difficulties. Teachers were trained in the use of digital platforms, but academic follow-up was uneven due to a lack of direct interaction and some students' disinterest in virtual classes.

During the pandemic, this school adopted a combination of digital tools such as Google Classroom, WhatsApp, Teams and Google Chat to continue teaching and academic follow-up.

Students reported a mixed experience of the effectiveness of these tools. Some found that these platforms facilitated the organisation and submission of assignments, while others faced difficulties due to the lack of direct interaction with teachers.

The transition to a hybrid model also presented challenges, as staggered attendance and the use of digital media did not always replicate the effectiveness of face-to-face teaching. Despite these problems, many students valued the use of digital tools and suggested that certain practices, such as the use of Google Classroom for homework submission, should be maintained even in a post-pandemic environment.

Students highlighted that while some online teaching strategies were effective, the lack of face-to-face contact affected their learning. Some mentioned that digital platforms helped to maintain communication and follow-up, but also pointed to the need for more engagement from teachers to ensure better understanding of the topics. Homework overload and the lack of a proper balance between online and face-to-face activities were recurrent problems that negatively affected academic performance.

The transition to online education presented numerous challenges for both students and teachers. Academic monitoring became more complex due to a lack of digital skills and adequate technological infrastructure.

The report reveals that although significant efforts were made to adapt teaching practices to a virtual format, the lack of adequate preparation and resources limited the success of these initiatives.

c. Educational quality:

Educational quality at the institution suffered during the pandemic, with a notable decline in students' academic performance on standardised tests such as the EXCOBA[1], administered at TUVCH. Overall, students reported that while some teachers adapted well to the new environment and provided useful resources, others failed to maintain the quality of instruction. The lack of direct interaction and reliance on self-study also contributed to this decline in educational quality.

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In addition, students mentioned that the quality of education varied significantly depending on the commitment of teachers and their ability to use digital tools effectively.

Despite these challenges, it was recognised that some tools and practices adopted during the pandemic could be useful in the future if properly integrated with face-to-face teaching.

The need for a balanced approach that combines the best of both worlds is essential to improve the quality of education and ensure that students receive a well-rounded and effective education.

Some of the teaching and academic monitoring practices implemented were:

- Digital platforms and online classes: Digital platforms were used to continue teaching, but the lack of digital competences in both students and teachers affected the effectiveness of these tools.
- Tutoring and mentoring: Tutoring programmes were implemented to support students, although the lack of direct contact and isolation negatively affected motivation and academic performance.
- Need for socio-emotional support: The importance of providing socio-emotional support to students to manage stress and anxiety stemming from the pandemic was highlighted.

Despite the challenges, the institution has maintained a consistent effort to ensure educational quality. Exit rates before and during the pandemic show a positive trend, with an overall exit rate of 69.84% in 2016 and increasing to 70.76% in 2019. Females showed a higher exit rate compared to males in most of the years analysed. (See figure 3).

Case Study School 3

School 3 is a secondary school offering a technological baccalaureate, located in an area with many economic, social and educational needs. (See graph 1). The COVID-19 pandemic exacerbated these challenges, significantly affecting educational quality.

Assessments showed a decline in proficiency levels in key areas due to the disruption of face-to-face classes and the transition to online education. Relevant data on School 3 is presented below.

a. Attrition and retention:

The institution faced a significant increase in attrition rates during the pandemic, which presented a critical problem. In 2016, the total attrition rate was 36.55%, and although there was a decrease in subsequent cohorts, the figures were still considerably high. During the pandemic, the attrition rate remained a major concern, affecting long-term student retention.

Data from generational cohorts reveal that attrition rates remained high, with factors such as failure and lack of access to technological resources as major contributors. (See Figure 2).

High attrition, especially in the early years, highlights the need for improved retention strategies and support for students, especially in adapting to online learning and managing emotional and academic load.

b. Academic monitoring and teaching and learning practices:

Due to time adjustments and the workload of EMI staff, the implementation of focus groups with teachers and students was not possible. However, according to the material reviewed, a pressing need to improve academic monitoring and teaching and learning practices was identified.

The data suggest that it is essential to implement personalised follow-up strategies for students, as well as to strengthen the digital competences of both teachers and students. In addition, it is crucial to develop socio-emotional and academic support programmes that respond to the specific needs that arise during and after the pandemic to ensure quality education and reduce dropout rates.

c. Educational quality:

Educational quality at School 3, a technological baccalaureate institution located in Valle de Chalco deteriorated significantly during the pandemic.

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Assessments indicated a decline in proficiency levels in key areas. Educational quality at this institution shows a gradual improvement in graduation rates, with an increase from 63.19% in 2016 to 65.46% in 2019.

However, the pandemic presented a significant challenge in maintaining this quality due to disruptions in learning and lack of adequate resources for online education.

Although final averages by generational cohort varied, with a slight improvement observed in the most recent generations, with averages ranging between 7.3 and 8.0, the results for entry to tertiary level, such as the TUVCH, show that overall the average upper secondary graduation rate is not consistent with the results on the EXCOBA diagnostic test.

The analysis suggests that the deficiencies in academic preparation are largely due to the disruption of traditional educational processes and the abrupt transition to online education.

Case Study School 4

School 4, located in Cerro del Tejolote, Ixtapaluca, faced significant challenges due to its context where students have different economic and socio-emotional needs, which put them in a vulnerable position (see Figure 1). (See Figure 1).

a. Attrition and retention:

This institution recorded a significant dropout rate during the pandemic. Economic factors and the need to work were the main reasons for dropout (see figure 2).

In terms of retention strategies, needs were identified as follows:

- Dissemination of activities: Television was used to disseminate educational activities and keep students informed.
- Support with materials: Textbooks were provided to those students who did not have access to the internet due to economic difficulties.
- Personalised follow-up: Through WhatsApp, phone calls and home visits, teachers and zone coordinators constantly followed up with students accompanied by guardians or parents.

b. Academic monitoring and Teaching and Learning practices:

Academic follow-up at the Institution was inconsistent, in addition to having the challenge of serving students with a reduced teaching staff. Online classes presented many challenges, including lack of internet access and devices suitable for students.

Faculty had to adapt quickly to digital platforms, but the quality of teaching was compromised.

Adapting to online education was a considerable challenge for the school. Lack of adequate technological resources and geographical constraints complicated the implementation of effective academic monitoring.

Some of the teaching practices reported were:

- Use of digital platforms: classes and activities were conducted via WhatsApp, Classroom and phone calls. These tools facilitated communication and the submission of assignments, although limited student connectivity presented a significant challenge.
- Checklists and attendance: To maintain academic control, checklists and attendance were used, as well as Classroom's tracking functionalities.
- Flipped classrooms: Practices such as flipped classrooms were implemented, where students reviewed reading materials prior to face-to-face classes, allowing for better planning and control of the topics covered.

c. Educational quality:

Educational quality in this school suffered during the pandemic. Although average grades increased slightly, this did not necessarily reflect better learning or understanding of the subjects. Information on academic outcomes is presented below:

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- Generational GPAs: Final GPAs for generational cohorts ranged from 7.75 to 7.81, with a slight increase in some semesters.

- Exam performance: Despite the apparently high averages, interviews suggest that grades did not always reflect students' true knowledge. The pandemic situation led to more empathetic assessment, considering students' personal and family difficulties.

- Adapted assessment: During the pandemic, students' assessment was adapted to consider their emotional and family situation, sometimes resulting in inflated grades.

- Lack of participation: There was a lack of participation by some students and teachers in updates and use of digital tools, which affected the effectiveness of distance learning.

Despite the challenges, the institution has made efforts to maintain the quality of education, with graduation rates reflecting an effort on the part of students as well as their teachers.

In 2016, the overall graduation rate was 57.62%, while in 2019 it was 59.09%, showing a continuous effort to maintain and improve these figures despite the challenges presented by the pandemic (see graph 3).

Below are graphs with information on the entry rate, attrition rate and exit rate for the four case studies.

[1] EXCOBA (Examination of Basic Competencies): Diagnostic test given at TUVCH.:

Box 6

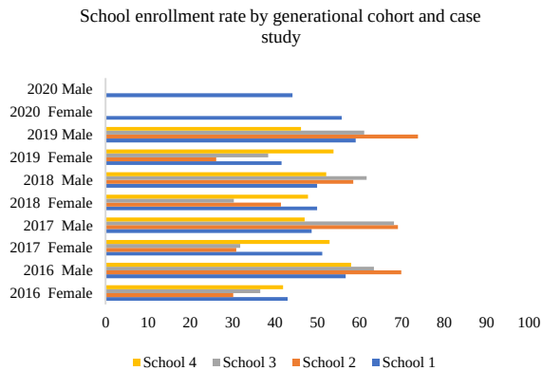

Figure 1

Entry rate by generational cohort and case study

Source: own elaboration 2024

Box 7

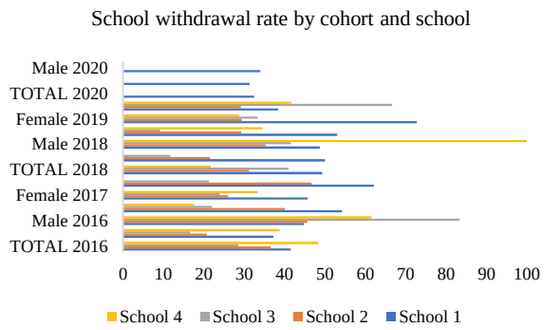

Figure 2

Departures by generational cohort and school

Source: Own elaboration (2024) with information provided by school authorities

Box 7

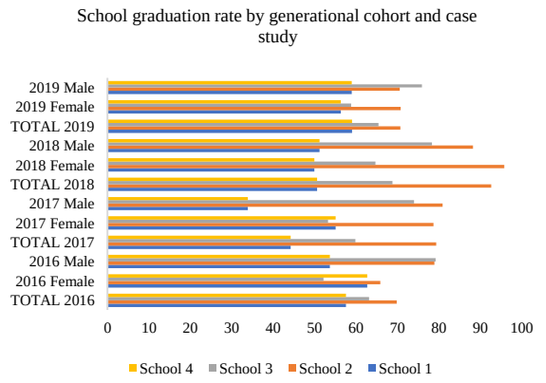

Figure 3

Graduation rate by generational cohort and school

Source: Own elaboration (2024) with information provided by school authorities

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After reviewing the four case studies, we observe that the data in table 6 are common to the IEMS considered in this study:

Box 8

Table 6

Incidence of problems in upper secondary education due to the impact of the pandemic by COVID 19

#	Her	Frequency	Remarks
1	School dropout	8	Main cause for concern across the rapporteurships.
2	Socio-emotional impact	7	Widespread concern for student welfare.
3	Digital divide and access to resources	6	Highlighted need for improved infrastructure and access.
4	Adaptation to virtual education	6	Challenges in transition and effectiveness of e-learning.
5	Need for retention and recapture strategies	8	Efforts to recapture students disengaged from the education system.
6	Inclusion and diversity	5	The importance of addressing the needs of vulnerable groups is highlighted.
7	Relationship with families	4	The importance of family support and commitment is emphasised.
8	Teacher training and use of technology	6	Recurrent need to improve digital skills and methodologies.
9	Follow-up of graduates	4	Interest in post-graduation follow-up to evaluate educational effectiveness.
10	Government collaboration and support	3	More support and specific public policies are suggested.

On the other hand, according to the results found in this research, the low scores, mostly ranging between 30 and 65 points out of 128 on the COMIPEMS high school entrance exam, indicate that students enter high school underprepared in key areas such as mathematics, science, and reading and writing skills.

This underachievement exacerbates the problem in their educational transition, a problem that was exacerbated by the pandemic due to the disruptions caused by COVID-19. This increased dropout rates and negatively affected the quality of education. The pandemic intensified these problems by imposing additional barriers, such as lack of access to technological resources and the need for many students to work to support their families.

The study on educational backwardness in the IEMS in Ixtapaluca, Valle de Chalco and Chalco has yielded several significant findings regarding the impact of the COVID-19 pandemic. We have analysed the impact, so far, on three main common aspects: school dropout, academic monitoring and teaching and learning practices, and educational quality. This allows us to answer one of our research questions:

- What is the impact of the pandemic in the IEMS of these municipalities, in relation to school dropout at all three levels?

The COVID-19 pandemic had a significant impact on the terminal efficiency of the IEMS in Ixtapaluca, Valle de Chalco and Chalco, as evidenced by the data on the graduation rates of the different generational cohorts analysed in the study. During the period of confinement, the institutions faced increased dropout rates due to factors such as lack of access to technological resources, the need to work to financially support their families, and the socio-emotional impact of isolation.

For example, in School 1, the exit rate decreased significantly in the 2019 and 2020 cohorts compared to previous years. Similarly, School 2 and School 3 also recorded a reduction in exit rates, reflecting the difficulties students faced in completing their studies in a virtual environment.

Taken together, these results underscore the need to implement academic recovery strategies and comprehensive support to mitigate the adverse effects of the pandemic on education, ensuring that students can reach their full academic potential in the future.

In summary, the pandemic highlighted existing problems such as dropout and terminal efficiency in the IEMS in these municipalities.

The combination of high dropout rates and grade inflation highlights the need to review education policies and assessment strategies to ensure that students not only remain in the education system, but also receive a quality education that effectively prepares them for the future.

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Conclusions

The IEMS in Ixtapaluca, Chalco and Valle de Chalco implemented various strategies to retain and follow up with their students in order to mitigate the impact of the pandemic.

These strategies included the use of digital platforms to maintain communication and academic follow-up, the delivery of content packs, as well as online activities and the loan of electronic devices.

However, these measures were not always sufficient to counter the challenges presented. Although school dropout was already a problem before the health crisis, the pandemic highlighted the difficulties related to academic quality.

The socio-emotional aspect considerably affected students, generating a negative impact that, after the pandemic, triggered other problems, such as increased anxiety and lack of motivation to continue their studies. In the area, there is a higher dropout rate among males than females, despite the fact that female enrolment is lower than that of males.

This poses an additional challenge for educational institutions to address gender disparities.

A crucial aspect during the pandemic was the almost personalised attention provided by counsellors and teachers, who played a pivotal role in monitoring and supporting students.

Their involvement with guardians or parents was also critical in order to create a more robust supportive environment. Despite these efforts, the main impact was reflected in declining proficiency levels in key areas such as mathematics and Spanish.

Students repeatedly mentioned that they do not feel confident in their knowledge and that their grades do not reflect their real performance, highlighting the importance of regularising the knowledge acquired. In addition, it was necessary to implement flexibility in school processes, including making late payments or definitively exempting some of them in exceptional cases, in order to contain dropout and facilitate educational continuity.

To face future challenges, more support from the authorities in terms of infrastructure and technology is required. Appropriate policies and strategies should be promoted that not only improve the quality of education, but also help to reduce dropout rates.

Furthermore, teacher training in techno-pedagogical skills must continue, ensuring that teachers are equipped to effectively use digital tools and adapt to new educational demands and implement interventions that respond to the specific needs of students is essential to promote meaningful learning as well as a more resilient and inclusive educational context.

During the research, a system of bulletins was created to address issues of education, drug addiction, training and gender violence through documentary research and focus groups with the community of the institutions participating in the research, resulting in 12 bulletins that included research advances, which were shared with the IEMS of Ixtapaluca, Chalco and Valle de Chalco, which allowed us to obtain more information for this study, as well as to strengthen our partnerships with them.

Final reflections

The implications for the future of this research underline the importance of investing in technological infrastructure and digital training for both students and teachers. In addition, it is crucial to implement socio-emotional support programmes that help students manage the stress and anxiety stemming from the pandemic.

Lessons learned during this crisis should be incorporated into education policies that promote greater equity and quality in education, ensuring an educational environment appropriate to the needs of young people.

The contribution of this research is the generation of information that can be used by educational authorities and institutions for the creation of policies and relevant strategies so that high school students can receive the necessary support to continue their studies and improve their quality of life.

This information also allows teachers and educational authorities to see the need to generate new ways or processes to improve their pedagogical practices and retention strategies.

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However, we recognise that a more refined analysis is still needed to sift through the data and reflect more on the needs and challenges that the COVID-19 pandemic has left us with in terms of educational backwardness.

To complement this analysis, four more cases will be included in the study that will give us a complete picture of the school situation of students during the pandemic, in terms of dropout, follow-up, emotional situation and the consequences in terms of educational quality; these case studies belong to the Ixtapaluca and Valle de Chalco areas.

Finally, we can highlight that the bulletin system is an example that allows us to have real information about the real needs of the IEMS for the formulation of relevant strategies to address the current challenges in the region of Ixtapaluca, Chalco and Valle de Chalco.In sum, this study provides an understanding of the challenges and opportunities facing the education system in these regions. Its findings, so far reported, and evidence-based recommendations are essential to design effective interventions to mitigate the adverse effects of the pandemic and strengthen the quality and accessibility of upper secondary education in the future.

Annexes

Box 9

Table 7

Statistical data for School 1

Indicator	2016	2017	2018	2019	2020
Total, enrolled students	118	242	160	132	120
Female enrolment rate	30.15%	51.20%	50%	41.60%	55.83%
Male intake rate	56.70%	48.70%	50%	59.09%	44.16%
Average intake	No data	No data	No data	No data	No data
Total dropout rate	41.52%	51.13%	49.37%	53.03%	32.50%
Total, female dropouts	37.25%	45.76%	50%	72.77%	31.34%
Total, male leavers	44.77%	62.09%	48.75%	38.46%	33.96%
Exit rate	57.62%	44.21%	50.62%	59.09%	No data
Female exit rate	62.74%	55.08%	50%	56.36%	No data
Male graduation rate	53.73%	33.87%	51.25%	58.97%	No data
Final average of generational cohort	7.6	7.6	7.4	7.4	No data

Box 10

Table 8

Statistical data for School 2

Indicator	2016	2017	2018	2019	2020
Total, enrolled students	63	68	41	65	No data
Female enrolment rate	30.15%	30.88%	41.46%	26.15%	No data
Male intake rate	69.84%	69.11%	56.70%	73.84%	No data
Average intake	8.1	8.2	8.4	8.4	No data
Total dropout rate	28.57%	22.05%	41%	9.20%	No data
Total, female dropouts	16.66%	23.88%	11.76%	33.30%	No data
Total, male leavers	83.33%	21.27%	41.60%	66.60%	No data
Exit rate	69.84%	79.41%	92.68%	70.76%	No data
Female exit rate	65.90%	78.72%	95.83%	70.83%	No data
Male graduation rate	78.94%	80.95%	88.23%	70.58%	No data
Final average of generational cohort	8.1	7.8	8.1	7.9	No data

Source: Own elaboration (2024) with information provided by school authorities

Box 11

Tabla 3

Statistical data for School 3

Indicator	2016	2017	2018	2019	2020
Total, enrolled students	145	157	122	139	No data
Female enrolment rate	36.55%	31.84%	30.32%	38.44%	No data
Male intake rate	66.44%	68.15%	61.67%	61.15%	No data
Average intake	7.88	8.1	8.1	7.7	No data
Total dropout rate	36.50%	40.12%	31.14%	34.53%	No data
Total, female dropouts	20.75%	26.00%	21.62%	29.41%	No data
Total, male leavers	45.65%	46.72%	35.29%	29.16%	No data
Exit rate	63.19%	59.87%	68.85%	65.46%	No data
Female exit rate	52.17%	53.27%	64.70%	58.82%	No data
Male graduation rate	79.24%	74%	78.34%	75.92%	No data
Final average of generational cohort	7.3	7.57	8.15	8	No data

Source: Own elaboration (2024) with information provided by school authorities

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Box 12

Tabla 4

Statistical data for School 4

Indicator	2016	2017	2018	2019	2020
Total, enrolled students	30	17	23	26	No data
Female enrolment rate	41.93%	52.94%	47.82%	53.84%	No data
Male intake rate	58.06%	47.05%	52.17%	46.15%	No data
Average intake	Sin datos	Sin datos	Sin datos	Sin datos	No data
Total dropout rate	48.38%	17.64%	21.73%	34.61%	No data
Total, female dropouts	38.80%	33.33%	0%	28.80%	No data
Total, male leavers	61.53%	0%	100%	41.66%	No data
Exit rate	57.62%	44.21%	50.62%	59.09%	No data
Female exit rate	62.74%	55.08%	50%	56.36%	No data
Male graduation rate	53.23%	33.87%	51.25%	58.97%	No data
Final average of generational cohort	7.75	7.75	7.8	7.81	No data

Source: Own elaboration (2024) with information provided by school authorities

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to have influenced the article reported in this paper.

Authors' contributions

Aldape-Enriquez, Elsa Georgina: I contributed with research coordination, liaison with participating IEMS, data collection and research development.

Flores-Valtierra, José Juan: I contributed with the initial visits to the IEMS, liaison with the IEMS and development of the research.

Mojica-Galaviz, Luis Alberto: I contribute with data collection and research development.

Torres-Valdés, Arturo: I contribute with data collection and research development.

Availability of data and materials

The data collection matrix, questionnaires, focus group scripts and conference information are available on request from the institution to which the lead author and her co-authors belong.

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Abbreviations

IEMS: Higher Secondary Education Institutions
INEGI: National Institute of Statistics and Geography

COMIPEMS: Metropolitan Commission of Public Institutions of Higher Secondary Education (Comisión Metropolitana de Instituciones Públicas de Educación Media Superior)

EXCOBA: Core Competency Examination

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Article

Soft skills in the graduate profile for the professional development of engineers

Habilidades blandas en el perfil del egresado para el desarrollo profesional del ingeniero

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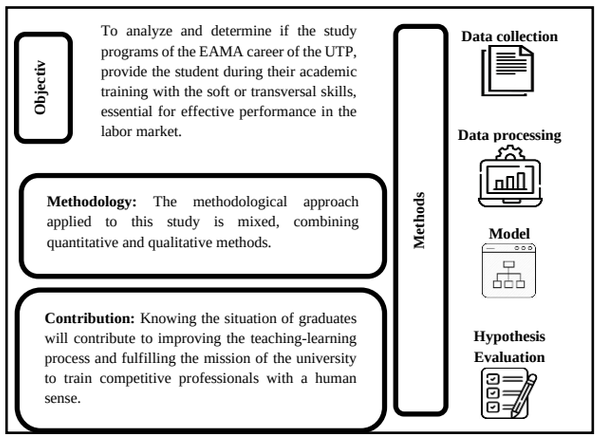
Abstract

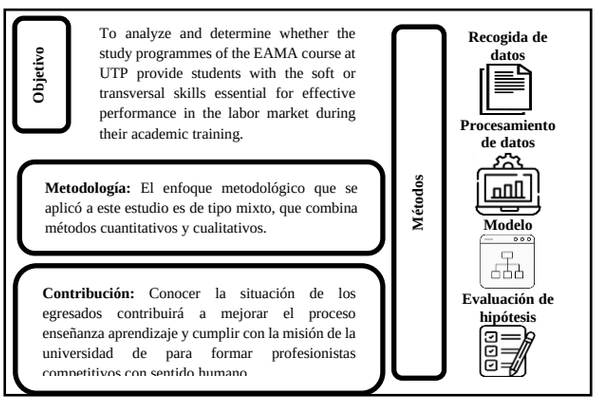
In a globalized and highly competitive world, people with leadership are required to make decisions critically and reflectively; Therefore, it is important to include in the student's professional training soft or transversal skills that allow them to function successfully in any area of life, mainly the work according to their graduation profile. The objective of this research is to analyze and determine if the study programs of the Alternative Energies and Environment (EAMA) career of the Technological University of Puebla (UTP), provide the student during their academic training with the soft or transversal skills, essential for effective performance in the labor market. Knowing the situation of graduates will contribute to improving the teaching-learning process and fulfilling the university's mission of training competitive professionals with a human sense who strengthen the processes of the productive and service sectors at the regional and national level that contribute to social development.



Competitiveness, Transversality, Reflective Critical Thinking

Resumen

En un mundo globalizado y altamente competitivo, se requiere de personas con liderazgo que tomen decisiones de manera crítica y reflexiva; entonces, es importante incluir en la formación profesional del estudiante competencias blandas o transversales que permitan desenvolverse con éxito en cualquier ámbito de la vida, principalmente el laboral de acuerdo con su perfil de egreso. La presente investigación tiene como objetivo analizar y determinar si los programas de estudio de la carrera de Energías Alternativas y Medio Ambiente (EAMA) de la Universidad Tecnológica de Puebla (UTP), proporcionan al alumno durante su formación académica las habilidades blandas o transversales, esenciales para el desempeño efectivo en el mercado laboral. Conocer la situación de los egresados contribuirá a mejorar el proceso enseñanza-aprendizaje y cumplir con la misión de la universidad de formar profesionistas competitivos con sentido humano que fortalezcan los procesos de los sectores productivo y de servicios a nivel regional y nacional que coadyuven al desarrollo social.



Competitividad, Transversalidad, Pensamiento crítico reflexivo

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Introduction

The higher education system in Mexico has maintained a low profile in the global context due to the deficient impulse given to public policies; The social and economic development of a country is an integral process that has an impact on the living conditions of citizens who aspire to improve their well-being with equal opportunities to access education, health and a fairer and more sustainable society, considering educational investment as a fundamental factor to achieve this, training professionals capable of facing the challenges of participating in an increasingly globalised economy, of consolidating its democracy and of advancing towards greater equity and social participation.

With regard to Global Competitiveness, the World Economic Forum (WEF) shows an overview of Mexico's position; the report states that in the 2017-2018 period, the country ranked 46th out of 140 nations, with an improvement compared to the 2017 report.

Mexico moves from fourth to second position in Latin America, behind only Chile, surpassing Costa Rica and Panama. Compared to the BRIC bloc, we moved from fourth to third place, above India and Brazil. The new ranking is headed by the United States, Singapore and Germany.

In this area, it is important to highlight that the three most problematic factors identified for doing business in the country are corruption, crime and inefficient government bureaucracy (WEF, 2018).

Consequently, Mexico requires significant reforms, as well as building good governance of its higher education system to strengthen quality.

The OECD (2020), in its publication '*The Challenges and Opportunities for Higher Education in Mexico*', recommends that higher education institutions should have clear objectives, and that federal and state authorities should be assigned well-defined and complementary responsibilities. To this end, a new Higher Education Law should be implemented to establish a legal framework that provides clarity and certainty.

For its part, ANUIES (2018), in the document '*Mission Vision 2030'* states that in the coming years the conversion of Information and Communication Technologies (ICT) to Learning and Knowledge Technologies (LKT) will be accelerated in all educational spaces, whether face-to-face, distance, hybrid or open.

Díaz-Barriga (2020) also sees the digital education programme as a broad example of promoting social inequality.

This is not to disqualify the efforts of the education authority to bring teachers closer to the use of digital technologies for the classroom, as this is an imperative need of our time, but to question to what extent this is the appropriate response to promote student learning in this situation.

There fore, it is necessary to modify the rigid and disciplinary conception of educational programmes to give way to flexible learning where there are alternatives as to how, when, where and what to study; the student will be the centre in the teaching-learning processes and experiential and active learning will play a key role in the formation of the competences necessary for the 21st century; research will increasingly become the support for training and educational institutions will make a significant contribution to the development of their environment.

In this case, the responsibility of HEIs is to respond to the needs of society, consolidated and autonomous in order to provide the knowledge and skills needed by the student, appropriate to the mission of the institution to improve the quality of education, which must be linked to relevance, and must receive the same attention in institutional evaluation processes.

In this context, the challenge for HEIs will be to train the student in new pedagogical educational models that contemplate higher-level competences, which contribute to developing a career path in line with the flexibility demanded by contemporary society, which since the beginning of the 21st century has accelerated the use of digital, physical and biological technologies, enabling new developments in the fields of artificial intelligence, automation, communication and work.

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These new trends have affected young people's behaviours with regard to how they interact, communicate, obtain information, participate in democratic processes and occupy their leisure time; they have even affected the learner's attitude to acquiring their learning.

While the mission of education is to prepare students to acquire knowledge, innovate, solve problems and perform complex tasks, some experts agree that much of the knowledge, technical skills and competencies being developed today in classrooms around the world will become obsolete for the jobs of the future.

UNESCO's 2023 report *"The Futures We Build* ' similarly warns that this mismatch is risky between job seekers and market supply, and sociologists have shown that a highly educated population that is unable to apply its competencies and skills in a decent job leads to dissatisfaction.

Derived from this, it is important to mention the current situation of Technological Universities in Mexico, and that according to ANUIES data from 2022, the Mexican higher education system brings together a little more than five million students at all levels. Of these, around one in five (1 million 46 thousand) are enrolled in public technological institutions. However, enrolment in technological higher education, which had remained relatively stable until the 2019-2020 school year, has registered a small decline over the last two school years, of around 3%, mainly due to the COVID-19 pandemic.

This experience shows that distance education programmes, whatever their modality - online, radio or television - have their limits and have exacerbated the structural educational gaps that already existed in the region prior to the pandemic, increasing the risks of school dropout and the gaps in learning and skills formation (Huepe, Palma and Trucco, 2022).

This shows that the development of student skills such as motivation or resilience, among others, is relevant in order to contribute to their learning process and allow them to adapt to social changes, which, in many cases, is not only about the education system in terms of the knowledge imparted, but also about the lack of these skills that will be essential to achieve the best educational and work performance.

For this reason, competences developed in higher education, both discipline-specific and transversal, can improve the economic well-being of individuals and support the productivity, innovation and economic growth of nations; both cognitive and non-cognitive socio-emotional or 'soft' skills are now in demand by employers.

For example, Acosta et. al. (2017), state that more companies train their workers in social-emotional skills than in technical skills, a finding consistent with the greater difficulty in finding employees with social-emotional skills.

One of the five regional commissions of the United Nations, committed to contributing to the economic development of Latin America and the Caribbean (ECLAC), refers to soft skills as 'skills for the future' or *soft skills* in the industry or labour context, and defines them as the skills that allow people to interact in and with their environment to enhance a digital world, promote innovation and integrate any type of trend, no matter how technical it may be (ECLAC, 2020).

For this commission, the topic has gained great relevance and is reflected in the analysis of the following studies and surveys:

- *The Future of Skills Employment in 2030* (Bakshi et al., 2017).

- *Future Skills-The future of Learning and Higher education* (Ehlers and Kellermann, 2019)

- *The Future of Jobs Report* (WEF, 2018)

- *Conceptual learning framework. Skills for 2030* (OECD, 2019)

These four studies are more focused on skills development than on competences; this is why the skills mentioned in each of them coincide in essence, but not in nomenclature.

As a result of the above, a table was drawn up showing the ten skills on which they agree. For each of these skills, the justification or need to develop the skill is integrated with some of the indicators proposed in the four studies:

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Box 1

Table 1

Ten key skills to develop according to the most impactful surveys worldwide

Ability	Justification	Indicators
Learning ability (learning to learn)	It is necessary to learn how to use the knowledge already learned to acquire new skills to respond to emerging needs. As Alvin Toffler said: 'The illiterates of the 21st century will not be those who cannot read or write, but those who cannot learn, unlearn and relearn'.	- Concentration - Organization - Enquiry - Task monitoring - Self-assessment of strategies Perseverance
Adaptability and handling of frustration	Mistakes and setbacks are part of life, the important thing is to know how to handle them in order to achieve success and the goals set in the short, medium and long term. "Yesterday's solutions do not solve tomorrow's problems.	- Acceptance, willingness and participation in changes in the shortest time possible - Tolerance - Flexibility as opposed to rigidity, immobility, inability to modify behaviour and generate new responses to change or new situations.
Collaboration	A globalised and hyper-connected world demands knowing how to work with others no matter where they are. Knowing how to collaborate, share knowledge and contribute in teams to achieve the expected results are key skills.	- Working together in pairs or groups - Sharing responsibility - Making meaningful decisions for the achievement of the product Interdependence
Verbal and written communication	Knowing how to express your ideas, products or services to others, based on the needs of the audience and the type of message to be conveyed. Empathy is an essential part of authentic communication with others.	- Extended or multimodal communication - Designing a product for a particular audience
Creativity and innovation	In a world of continuous change it is important to look beyond the present and imagine future possibilities. Curiosity, questioning and research help to develop new ideas and solutions to current problems.	- Originality: refers to what is new, unique, unrepeatable and authentic. - Productivity or fluency: refers to the number of answers and solutions given. - Open-mindedness: refers to the ability to face challenges and obstacles and to solve them. - Sensitivity to problems: empathy to perceive and discover difficult and problematic situations - Redefinition: ability to find uses, functions, applications and definitions different from the usual ones. - Level of inventiveness: ability to perceive reality and transform it partially or totally.
Problem solving and decision making	Analysing the causes and consequences of a problem and making decisions that allow for its solution are key skills to face any present and future challenge.	- Identify key ideas - Identify causes and consequences - Analyse and evaluate solutions - Evaluate and improve solutions - Accept and value diverse points of view
Critical thinking	Analysing the veracity of a fact or information to identify trends.	- Interpret data and information - Compare information - Drawing conclusions - Analyse and evaluate information
Information and data management	Access to a world of constant information demands the ability to analyse, contrast, evaluate and infer.	- Search for information from various sources - Analyse and assess the veracity of the data - Select and validate data and information - Compare information - Synthesise and organise information - Produce diagrams and graphs - Disseminate information
Leadership	Train, motivate and guide others to do their jobs better, as well as know how to negotiate to achieve objectives.	- Empathy - Proactivity - Leadership
Technology and computational thinking	Technology is changing at an unprecedented pace, so it is important to teach the strategies to manage any type of technology and not only the current or available in your context. Hence the importance of working in areas such as programming, STEAM and robotics.	- Systems thinking - Process analysis - Process documentation - Task analysis - Algorithmics - Robotics - Operation of basic tools - Troubleshooting

Source: (ECLAC), 2020. Economic Commission for Latin America and the Caribbean (ECLAC)/Organization of Ibero-American States for Education, Science and Culture (OEI), "Education, youth and work: skills and competencies needed in a changing context".

Objective of the research

To analyse and determine whether the study programmes of UTP's EAMA programme provide students with the soft or transversal skills essential for effective performance in the labour market during their academic training.

Hypothesis

With the development of soft or transversal skills in their academic training, students will contribute to their graduate profile the non-cognitive competencies they need for an adequate labour market insertion, applying their reflective critical thinking in the solution of problems, ethical and responsible decision making, and which will allow them to develop successfully in any area of life.

Methodology to be developed

This work focuses on the UTP, in the EAMA course. In 1991, Technological Universities (UUTT) were created as a result of the process of diversification of technological higher education in Mexico and the complexity in the management of this sub-system, oriented to face different challenges of the labour market and meet the emerging productive needs in the face of the imminent process of commercial opening that the country was experiencing. The UUTTs also emerged as a response to Mexico's lack of a wide range of Higher University Technical Education programmes (Fassnacht, 2023).

The methodological approach applied to this study is of a mixed type, combining quantitative and qualitative methods to provide more complete and holistic information on the phenomena studied.

The approach is an analytical one that presents the experiences obtained from people who make up a given social environment; it involves the employers of the companies in which the graduates have provided their services to fulfil their professional stays in the EAMA career.

Surveys were applied to employees to capture the hard and soft skills that graduates of the EAMA Division develop in the workplace; also, face-to-face meetings are held with the career director to obtain information on the performance of graduates in the workplace.

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Their contributions were considered to establish recommendations about the contents of the educational programme, valuable information for the area of improvement.

To achieve the objective of this research, an analysis and comparison was made of the learning sequence of the study programmes with the soft skills and indicators established by ECLAC (2020), in accordance with Table 1, to determine whether the UTP Renewable Energy Engineer meets the knowledge, skills and competences defined in the graduate profile of the degree programme to perform successfully in the labour market.

In this context, the Ministry of Energy (2016) refers that Mexico is committed to meeting the mitigation goals established in the Law for the Use of Renewable Energy and the Financing of Energy Transition (LAERFTE), which states that the electricity sector must be transformed so that by 2024 a maximum of 65% of electricity comes from fossil fuels. This goal is ratified in the General Law on Climate Change, which stipulates that 35% of electricity generation should come from clean energy by the same year. It is therefore essential that UTP students meet the following graduate profile for the EAMA programme.

Design and manage energy projects by integrating innovative technologies based on renewable energy sources to respond to customer needs. Propose alternative energy solutions and improvements, model the energy system and determine the economic feasibility of the design.

Results

According to the meetings held with the employers of the companies that hire EAMA graduates, the employers present mentioned the skills that most of the graduates lack and which are of utmost importance for the development of their functions:

- Ability to acquire learning.
- Identifying opportunities.
- Managing emotions.
- Decision making.
- Reading habits to increase culture, both in technical subjects and in general.
- Ability to write texts.
- Initiative and proactivity.
- Knowledge and interpretation of the quality management system, international and national standards.
- Collaboration with multidisciplinary teams.
- Responsibility and empathy.
- Analytical skills.
- Apply ethics.
- ICT skills.

As a result, it was found that graduates lack the soft skills proposed by ECLAC, which was considered as a guide for this study. To determine this situation, the contents of the study programmes were analysed to identify whether they include the soft skills and indicators established by ECLAC. Below are the subjects that should be reinforced so that students can strengthen their soft or socio-emotional skills, complement their hard skills and comply with the graduate profile of the degree programme; recommendations are also made regarding study strategies and practices that will enable graduates to adapt to the current demands of the labour market:

Oral and Written Expression I

Objective of the subject

The student will write projects based on Level B2 of the Common European Framework of Reference for Languages, considering the grammatical bases, the organization and structuring of ideas, the expression of their own points of view and positions and those of other authors, in order to contribute to solving current problems linked to their professional and socio-cultural context.

Learning units

I. Grammatical bases for the construction of ideas.
II. Organization and structuring of ideas
III. Introduction to writing

Result of the analysis

This is one of the subjects that integrates the common core for the integral development of the student; in the analysis of the content of the subjects it is concluded that the learning sequence does not contemplate the basics for the student to acquire the skills needed to develop creativity and innovation, problem solving, critical thinking, data management and information.

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Recommendations

A *basic Thinking Skills Development (TSD) workshop* should be considered in this programme. For the authors Pereira et al. (2024), PTS are mental abilities that allow them to process information, analyse it, synthesise it and reach logical and reasoned conclusions. These skills are fundamental for learning and problem solving in any field, whether in education, work or everyday life.

Although basic skills are acquired during the early years of education, most students have only developed habits of intellectual inhibition.

The DHP involves essential skills such as observation, relation, description, classification and comparison and inference that are essential for cognition and that facilitate the processes of organisation and perception, which, with the practice of these, can generate intellectual maturity in the student that will facilitate the learning of more complex subjects such as logic, mathematics, physics, chemistry, among others.

Oral and Written Expression II

Objective of the subject

The student will support written and oral projects based on the process of communication, argumentation and types of texts and documents according to Level B2 of the Common European Framework of Reference for Languages in order to achieve effective communication in a professional and socio-cultural context.

Learning units

I. The communication process
II. Effective communication in organizations.

Result of the analysis

The content of the learning sequence resulted in a lack of application of the soft skills of adaptability and frustration management, collaboration, creativity and innovation, problem solving and decision making, critical thinking, data information management and leadership.

Recommendations

Effective communication is one of the soft skills that is highly relevant to the holistic development of the learner. Traditional teaching of oral and written expression is very rigid; it asks the learner to memorise spelling and grammatical rules; however, this will not lead to the level of understanding of meaning that is enhanced through the acquisition of the skill of reading to learn to speak.

The results obtained in the year 2022 in the OECD Programme for International Student Assessment (PISA); determined that in Mexico there is a generalised deficiency in reading comprehension, which is a crucial skill for life, as it allows interacting with the world effectively, acquiring knowledge, strengthening personal development and becoming an active part of the environment; also, the expression of meaning is developed through the acquisition of the skill of writing to learn to write, which brings as a consequence that, when acquiring linguistic skills, logic and syntax are learnt.

This process will lead the learner to think and, through motivation, to organise his or her thinking in order to generate reasoning.

This programme should be complemented with a *reading workshop* that favours reading comprehension, develops the habit of reading and activates creativity, innovation and data information management in order to find the right solution to any situation.

Follow up the *DHP programme: Inductive, deductive, hypothetical and analogical reasoning process.*

Integrative

Aim of the subject

The student will demonstrate the competence to formulate renewable energy projects through energy diagnostics and specialised studies of the natural resources of the environment in order to contribute to sustainable development and the rational and efficient use of energy.

Learning units

I. Case analysis and approach
II. Project development

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Outcome of the analysis

The subject Sociocultural Training I laid the foundations for the student to develop most of the soft skills proposed in this study through: integrating a life and career plan; knowing, analysing benefits and presenting a sustainable development model; establishing work strategies through team management, conflict resolution and decision making to contribute to the achievement of the organisation's objectives; consequently, in Sociocultural Training II the student is prepared for teamwork based on its dynamics, communication style and roles of the members to generate collaborative synergy among its members.

This collaborative work is developed in the integrative subject, where students will develop the competences that will enable them to form part of a team to 'Formulate renewable energy projects by means of energy diagnoses and specialised studies of the natural resources of the environment to contribute to sustainable development and the rational and efficient use of energy'.

The integrative subject does not follow a structured methodology for the formulation of projects, and in this case to achieve the objective of the subject. Therefore, in order to achieve the graduate profile, it is essential that students master the research tools that give them the opportunity to manage, apply and convert information from different situations to provide solutions to problems; acquire analysis and synthesis skills for the development of documentary research; improve oral and written communication with the support of ICT; write and present their ideas to an audience, produce writings and identify scenarios in their professional field.

Given this panorama, the great technological changes demand the creation of new educational programmes based on the care of the environment and the use of alternative energies, for this reason the need arises for the Engineer in EAMA to have the soft skills that allow him/her to develop entrepreneurial projects.

Therefore, a *research methodology course* is proposed, in which the student presents a protocol or plan of action to carry out a scientific study.

It is also proposed to combine the subject programme with the *DHP workshop: Creativity.*

Modern trends, globalisation, digitalisation and demographic change have significantly influenced the behaviour of individuals, which is reflected in the way they socialise, work and their ability to evolve culturally and socially. In this context, the use of technology is immersed in students' education, although there are indications that some find it difficult to enter into this dynamic, making the practice of the soft skills of technology and computational thinking deficient.

In the research '*Resistance to digital change, a factor that affects learning and impacts on the academic performance of university students*', the authors Moreno and Sánchez (2023), believe that university students will achieve academic performance when they acquire the necessary attributes to develop their self-directed learning process and appropriation of knowledge; therefore, they must broaden their horizons and change their culture to generate outstanding, innovative ideas; to carry out actions beyond the everyday, aimed at stimulating reflective critical thinking with a creative attitude; where major technological changes demand committed professionals to perform in adverse situations, but with firm criteria to make good decisions, in which they combine disciplinary and transversal competences to achieve comprehensive training.

Conclusions

In relation to the results obtained and validating the hypothesis put forward in this research, it is determined that, by developing soft or transversal skills in their academic training, students will have the ability to develop responsible and ethical practices for the benefit of energy sustainability, economic, social and ecological development of their environment, with the ability to achieve professional and personal success.

Therefore, it is essential that the student develops a social and ecological entrepreneurial awareness, as well as a paradigm shift in habits and customs, with skills to apply knowledge, behaviours and values that contribute to meeting the graduate profile.

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The educational function should not only contribute to student learning, but also motivate them to act as agents of change; this is fundamental for social and labour inclusion and increased productivity. Likewise, the University's responsibility is to adopt the proposals for improvement by training teachers in this change of paradigms and to achieve educational quality.

Declarations

Conflict of interest

We, the authors, declare that we have no conflicts of interest. We have no known competing financial interests or personal relationships that could influence the reported article.

Authors' contribution

Moreno-Aguilar Ma. Antonia: Contributed with the idea of the project, organization and development of the research.

Sánchez-López, Guillermina: Contributed to the development of the research, analysis of the information, revision and editing.

Luna-Aguirre, Jaime: Contributed to the analysis of the information and revision of the results.

Reyes-Oliver, Irma: Contributed to the methodology, interpretation of the data collected and editing.

Availability of data and materials

The data used and analysed in this research are available on request from the corresponding author.

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Abbreviations

ANUIES	National Association of Universities and Higher Education Institutions (Asociación Nacional de Universidades e Instituciones de Educación Superior)
CEPAL	Economic Commission for Latin America and the Caribbean
DHP	Development of Thinking Skills
EAMA	Alternative Energies and Environment
ER	Renewable Energies
IES	Higher Education Institutions
LAERFTE	Law on the Use of Renewable Energies and the Financing of the Energy Transition
OCDE	Organization for Economic Co-operation and Development
PISA	Programme for International Student Assessment
TAC	Learning and Knowledge Technologies
TIC	Information and Communication Technologies
UNESCO	United Nations Educational, Scientific and Cultural Organization
UTP	Technological University of Puebla
UUTT	Technological Universities
WEF	World Economic Forum

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Article

Identification of priority cases for attention to the academic performance of students by subject

Identificación de casos prioritarios para atención en el desempeño académico de los estudiantes por asignatura

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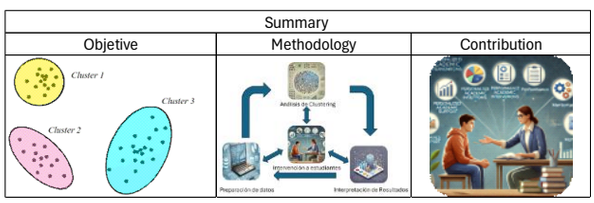
Abstract

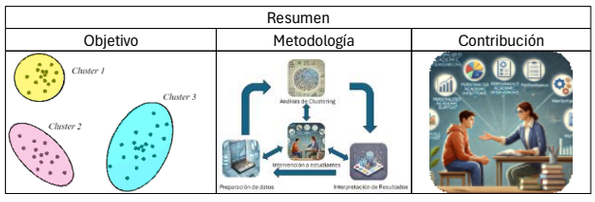
Identifying priority cases to improve students' academic performance by subject has gained relevance in modern education, and artificial intelligence (AI) emerges as a fundamental tool to achieve this. Through cluster analysis, an unsupervised learning technique, it is possible to group students according to specific performance patterns and needs. This allows educational institutions to quickly recognize which cases require priority attention and focus their resources efficiently. Cluster analysis makes it possible to identify segments of students with similar characteristics in their academic performance, revealing aspects such as recurring difficulties in certain subjects, learning patterns, and factors that affect performance. With these defined groups, teachers and administrators can establish personalized and effective intervention strategies. For example, specific support programs can be developed for students facing problems in mathematics or science, rather than applying general solutions. AI applied in this context not only helps to categorize students, but also allows for a more accurate prediction of who may need additional support in the short and long term. Furthermore, by identifying common factors within each cluster, it is possible to improve teaching methods and design curricula that are more adapted to the real needs of students. This practice not only promotes inclusive and student-centered education, but also optimizes the use of academic resources by focusing efforts on the most urgent cases. The application of cluster analysis in the identification of priority cases for academic attention represents a key innovation in the educational sector, allowing for more personalized, inclusive and effective education, supported by artificial intelligence.



Artificial Intelligence, Cluster Analysis, Academic Performance

Resumen

La identificación de casos prioritarios para mejorar el desempeño académico de los estudiantes por asignatura ha cobrado relevancia en la educación moderna, y la inteligencia artificial (IA) emerge como una herramienta fundamental para lograrlo. A través del análisis de clúster, una técnica de aprendizaje no supervisado, es posible agrupar a los estudiantes según patrones específicos de rendimiento y necesidades. Esto permite que las instituciones educativas reconozcan rápidamente cuáles son los casos que requieren una atención prioritaria y enfoquen sus recursos de manera eficiente. El análisis de clúster permite identificar segmentos de estudiantes con características similares en su desempeño académico, revelando aspectos como las dificultades recurrentes en ciertas asignaturas, patrones de aprendizaje y factores que afectan el rendimiento. Con estos grupos definidos, los docentes y administradores pueden establecer estrategias de intervención personalizadas y efectivas. Por ejemplo, se pueden desarrollar programas de apoyo específicos para los estudiantes que enfrentan problemas en matemáticas o ciencias, en lugar de aplicar soluciones generales. La IA aplicada en este contexto no solo ayuda a categorizar a los estudiantes, sino que también permite una predicción más precisa de quiénes pueden necesitar apoyo adicional a corto y largo plazo. Además, al identificar los factores comunes dentro de cada clúster, es posible mejorar los métodos de enseñanza y diseñar currículos más adaptados a las necesidades reales de los alumnos. Esta práctica no solo promueve una educación inclusiva y centrada en el estudiante, sino que también optimiza el uso de los recursos académicos al focalizar los esfuerzos en los casos más urgentes. La aplicación del análisis de clúster en la identificación de casos prioritarios de atención académica representa una innovación clave en el sector educativo, permitiendo una educación más personalizada, inclusiva y efectiva, con el respaldo de la inteligencia artificial.



Inteligencia Artificial, Análisis de Cluster, Desempeño académico

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Introduction

Today, identifying students at academic risk has become a priority for educational institutions seeking to improve educational outcomes and quality. With the rise of artificial intelligence (AI), advanced data analysis techniques, such as cluster analysis, have proven to be powerful tools for detecting patterns of underachievement that would otherwise go unnoticed in traditional education (García-Martínez *et al*., 2023). This type of analysis allows students to be segmented into groups with similar characteristics and needs, thus facilitating the identification of priority cases that require immediate intervention to improve their performance in different subjects.

The application of cluster analysis in education offers an innovative perspective for understanding academic behaviour and the factors that influence student performance. This approach, powered by AI algorithms, allows not only to classify students, but also to tailor interventions and support strategies to their specific needs. The methodology is based on the collection of detailed data on performance in each subject, the normalisation and selection of key variables, and the application of clustering techniques to group and prioritise cases (Kulik & Fletcher, 2015).

The early identification of students at academic risk has gained relevance in recent years due to its impact on student success and the efficiency of educational institutions. Artificial intelligence (AI) techniques, specifically cluster analysis, have emerged as effective methods for segmenting and prioritising student cases that require immediate attention. These tools can identify patterns in academic data and provide personalised interventions, optimising institutional resources and improving the educational experience. Studies have shown that cluster analysis can significantly improve accuracy in classifying and predicting academic performance compared to conventional methods (Adelson & McMullin, 2017).

Early studies in this area focused on the use of traditional statistical methods for the identification of at-risk students. However, with the advancement of AI technologies, a more dynamic and accurate approach has been achieved.

For example, McLaren *et al*. (2017) demonstrated how intelligent tutoring systems, integrated with data analytics, can significantly improve learning in specific areas of mathematics and science. These systems, based on algorithms that detect patterns of behaviour and performance, offer more effective and targeted interventions, and their application has spread rapidly in different educational contexts.

Recent studies, such as that of García-Martínez *et al*. (2023), have gone a step further by employing cluster analysis methods to segment students according to critical performance factors. This approach, supported by AI techniques, allows students to be classified into homogeneous groups, facilitating the implementation of personalised support plans that are tailored to the specific needs of each group. In contrast to previous studies, this work combines cluster analysis with increased data processing power, allowing large volumes of information to be assessed in real time and to respond quickly to changes in academic performance.

This study explores how cluster analysis, in combination with artificial intelligence, can transform the way academic support is addressed, ensuring that the most at-risk students receive personalised and effective attention. The implementation of these analytical techniques allows not only to improve educational quality, but also to optimise the use of resources in academic institutions, focusing efforts on those students who need it most.

Methodology

Development of the Methodology:

In the methodology to be followed in the research was carried out under a descriptive approach as it is key to accurately document the data, describes in detail the patterns of student performance, the interpretation resulting from cluster analysis and preparation methods, knowledge, ways to structure strategies for intervention with students.

To address the problem of identifying priority cases in students' academic performance by subject using artificial intelligence techniques and cluster analysis, the following methodology is proposed:

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1. Data Collection:

– Academic Data: Collect detailed information on students' grades in each subject, including midterm grades, final exams and practical work.
– Behavioural Data: Record class attendance, participation in extracurricular activities and use of educational platforms.

2. Data Preprocessing:

– Data Cleaning: Eliminate incomplete or inconsistent records.
– Normalisation: Standardise variables to facilitate analysis.
– Coding: Transforming categorical variables into numerical ones.

3. Variable Selection:

– Identify the most relevant variables that influence academic performance, using statistical and machine learning methods to determine their significance.

4. Cluster Analysis:

– Application of Algorithms: Use clustering algorithms, such as K-means or DBSCAN, to group students according to similar patterns in their academic performance.
– Determining the Number of Clusters: Use methods such as the elbow method or the silhouette score to identify the optimal number of clusters.

5. Interpretation of Results:

– Cluster Profiling: Analyse the characteristics of each cluster to understand differences in performance and associated factors.
– Identification of Priority Cases: Detect clusters that represent students with low performance or academic risk, prioritising their attention.

6. Implementation of Interventions:

– Strategy Design: Develop specific action plans for each identified cluster, such as personalised tutoring, study skills workshops or psychological support.
– Monitoring and Evaluation: Establish indicators to measure the effectiveness of interventions and make adjustments as needed.
– Feedback and Continuous Improvement: Use the results obtained to refine the analysis model and intervention strategies, ensuring constant improvement in the identification and attention of priority cases.

Results

The implementation of a cluster analysis supported by artificial intelligence in the educational field seeks to identify and classify priority cases for intervention in the academic performance of students, according to their performance in different subjects. It is expected that this tool will enable educational institutions to:

1. Identify patterns of performance: using advanced grouping techniques, it is expected to detect groups of students with similar characteristics in their performance, which will facilitate specific and targeted intervention.

2. Improve the effectiveness of interventions: By targeting efforts to the students who need it most, an increase in the effectiveness of academic support programmes is expected.

3. Optimise resources: By prioritising critical cases of academic performance, resources can be focused on the areas and students with the greatest needs, maximising the impact of educational strategies.

4. Narrow the learning gap: Personalisation of teaching strategies will help to narrow the achievement gap between students, creating a more inclusive learning environment.

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Cluster analysis has become an essential tool in education to identify patterns of student behaviour and performance. Three scientific investigations that apply clustering techniques in education are summarised below:

1. Cluster Analysis in Educational Data: A Quantitative Study of Responses to an Open-Ended Questionnaire 2.

Battaglia, Di Paola and Fazio (2015) explored the consistency of student responses in various educational contexts. They applied cluster analysis methods to group students according to similarities in their responses, without prior knowledge about the formation of these groups. The results allowed them to identify intellectually similar subgroups, providing a deeper understanding of student reasoning patterns.

2. Machine Learning Methodology for the Classification and Prediction of Users in Virtual Learning Environments.

De-La-Hoz, De-La-Hoz and Fontalvo (2019) developed a methodology for classifying and predicting user behaviour in educational virtual environments. They used machine learning tools, such as principal component analysis and clustering, to study students' interaction with the platform and their performance in exams. The methodology allowed them to identify categories of users and apply machine learning algorithms to classify students according to their level of knowledge, achieving 91% accuracy in predictions.

3. Unsupervised Cluster Analysis Based on Online Learner Behavioural Data.

Peach, Yaliraki, Lefevre, and Barahona (2019) introduced a mathematical framework for analysing time series of student online participation. They used a dynamic temporal alignment kernel combined with an unsupervised multiscale graph clustering algorithm to identify groups of students with similar behavioural patterns. The study revealed different patterns of engagement, from distributed to concentrated learning, and highlighted the methodology's ability to identify low-performing students more accurately than traditional classification methods.

This research shows how cluster analysis with artificial intelligence can be a powerful tool for improving academic performance through targeted and personalised interventions.

Conclusions:

The use of artificial intelligence through cluster analysis in education offers an innovative and efficient approach to improving academic performance. This tool allows educational institutions to identify, with high precision, priority cases that require intervention, thus achieving a more effective allocation of resources and a timely response to the needs of each student.

By segmenting students into groups with similar performance and behavioural characteristics, teachers can design personalised interventions that enhance learning, increase retention and reduce achievement gaps.

In addition, this approach allows for anticipation of learning problems and facilitates informed decision-making based on real data and specific patterns that might otherwise go unnoticed. By implementing this model, institutions also foster an inclusive educational environment, where every student receives the attention they need to develop their skills and reach their full potential.

Artificial intelligence and cluster analysis not only transform the way priority cases are identified, but also put education on a path towards personalisation of learning, benefiting both students and educators. This represents a significant step forward in the commitment to quality, learner-centred education adapted to current educational demands.

Potential for improvement

One possibility for improvement in the process of identifying and addressing priority cases in academic performance could be the integration of real-time feedback to students and teachers. By implementing continuous reporting and analysis systems, both students and teachers would receive early alerts on academic performance and progress in each subject.

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This would allow students to take proactive measures and access additional resources at the moment they face difficulties, rather than waiting for later interventions.

Furthermore, teachers would be able to adapt their methodology based on real-time data, applying differentiated strategies according to the individual needs of the group. This improvement would facilitate a more agile intervention, encourage self-assessment and autonomous learning, and contribute to a more dynamic learning environment that is more responsive to the academic challenges of each student.

Medium-term benefits

1. Improved academic performance: Timely intervention in priority cases will help students overcome specific difficulties in certain subjects, tangibly improving their performance in the short and medium term.

2. Optimisation of educational resources: By identifying and addressing critical areas, the institution will be able to focus resources and efforts on the students who need them most, optimising the use of staff, time and educational materials.

3. Increased student retention: Students who receive support and attention when they need it most are more likely to remain in the education system, reducing dropout rates.

4. Motivation and confidence in students: By receiving personalised attention and seeing results in their performance, students gain confidence in their abilities and maintain a positive attitude towards learning.

Long-term benefits

1. Development of autonomous and self-assessment skills: Constant exposure to a feedback system will enable students to develop self-assessment and self-management skills, valuable for their continuous learning and professional life.

2. Improved institutional reputation: Implementing advanced technology for educational support will strengthen the image of the institution as innovative and committed to the academic success of its students.

3. Reducing the learning gap: Attention to priority cases helps to level the performance of the student group, promoting inclusive learning that reduces differences in academic achievement.

4. Contribution to educational research: The data collection and results obtained from this project will serve as a basis for future research, driving new artificial intelligence initiatives in education and contributing to global knowledge on personalised learning.

Implementing this project not only has the potential to transform learning today, but also to lay a solid foundation for a more equitable and efficient education system in the long term.

Strengthening partnerships

This project offers an excellent opportunity to strengthen strategic partnerships with a variety of entities. Some ways in which this can be achieved include:

1. Collaboration with technology companies: establishing partnerships with companies specialising in artificial intelligence and data analytics will allow the institution to access cutting-edge technologies, receive expert advice and jointly explore new educational applications. These collaborations can also open doors for students and teachers to participate in training and joint projects, broadening their knowledge in the use of advanced tools.

2. Linking with universities and research institutions: Working hand in hand with other academic institutions will allow for the exchange of knowledge, methodologies and experiences on the use of artificial intelligence in education.

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These partnerships can lead to joint research, academic publications and the development of best practices that benefit both parties and ultimately the entire education community.

3. Partnership with governmental and educational bodies: By demonstrating the positive impact of the project, the institution can attract the attention of educational authorities and governmental bodies interested in promoting technology in education. This can translate into financial support, access to educational innovation programmes and opportunities to expand the project to a regional or national level, benefiting more students and communities.

4. Engaging with parents and student associations: Involving parents and student associations in the project can strengthen community engagement in students' education. By communicating the benefits of the project and the progress made, a bond of trust and collaboration is created that drives the success of the project and motivates students to make the most of these opportunities.

5. Connections with non-governmental organisations (NGOs) and educational foundations: Often interested in supporting inclusive education and bridging gaps, NGOs can provide financial or in-kind support to ensure the continuity of the project. In addition, NGOs often have educational resources and intervention expertise that can enrich and strengthen the implementation of the cluster analysis in the institution.

Strengthening these partnerships will allow the institution to expand the impact of this project, improve its technological and pedagogical capacities.

Authors' contribution

The authors made the following contributions to the article:

Fernández-Mena, Ana Laura: was responsible for the analysis of artificial intelligence algorithms that can be applied to the academic area, ensuring their suitability to the educational context and accuracy in identifying patterns of academic performance.

Torres-Magaña, María Patricia: led the overall coordination of the project, ensuring the effective integration of the various stages of the research.

Hernández-De la Rosa, Francisco Alberto: contributed to data collection and analysis, establishing the criteria for the selection of relevant variables and ensuring the quality and consistency of the relevant information in the study.

Rodríguez Fernández, Manuel Antonio: participated in the interpretation of the results obtained from the cluster analysis research, collaborating in the elaboration of conclusions and practical recommendations for their implementation.

These joint contributions made it possible to develop an innovative methodology that will allow us to detect and efficiently address the academic needs of students, optimising educational resources and improving performance in various subjects.

Acknowledgements

We are deeply grateful to the TecNM Campus Villahermosa for their vision and commitment to academic excellence by allowing us to research advanced artificial intelligence technologies in the analysis of student performance. Their support and dedication to the continuous improvement of education has allowed this project to be conceptualised, seeking to benefit not only students, but also teachers and the community in general. Thanks to their support, we have been able to analyse cluster analysis techniques to identify and prioritise the needs of students in each subject, promoting more inclusive, personalised and effective learning.

Your leadership in embracing research in technological innovations is an inspiration to all of us in education, and demonstrates a strong commitment to quality and the well-being of every student.

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We are grateful for their trust and unwavering support, which have been essential to the success of this initiative, and hope that together we can continue to build a more equitable educational future tailored to the individual needs of each student.

Abbreviations

TecNM	Tecnológico Nacional de México
AI	Artificial Intelligence
AI	Artificial intelligence
NGO	non-governmental organisation

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Background

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Article

Gamification for the development of soft skills in the engineering area

Gamificación para el desarrollo de las habilidades blandas en el área de ingenierías

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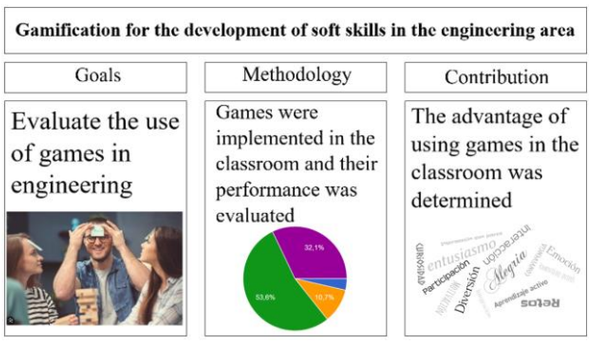
Abstract

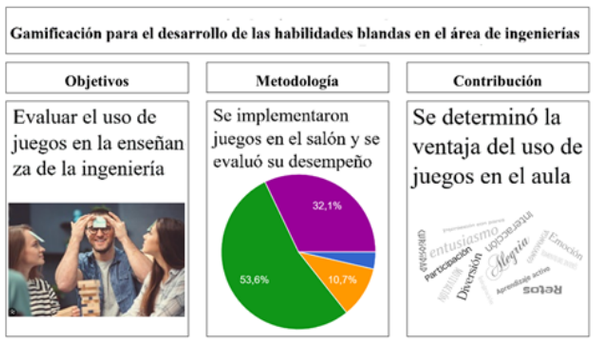
The application of the gamification technique brings benefits in many aspects among people who participate in this type of activities regardless of the environment in which they operate, noting that motivation and a positive attitude towards the role that they must develop in their social environment, work, educational or family benefits from being exposed to recreational activities, literature reporting in different studies that joy and a good attitude prevail. The study was carried out under the qualitative method, of the descriptive type, for the subject of Hydraulic Machines of the Electrical Mechanical Engineering degree, with a sample of 28 students. After the application of the evaluation instrument, the students reported feeling happy, cheerful, having socialized and interacted with their classmates in a way that had not happened for a long time, having reduced the stress generated by the subject and having learned actively and more easily. the themes.



Gamification, soft skills, learning environments

Resumen

La aplicación de la técnica de gamificación reporta beneficios en muchos aspectos entre las personas que participan en este tipo de actividades independientemente del entorno en que se desenvuelvan, señalándose que la motivación y la actitud positiva hacia el rol que les corresponde desarrollar en su entorno social, laboral, educacional o familiar se benefician al ser expuestos a actividades lúdicas, reportando la literatura en diferentes estudios que la alegría y la buena actitud imperan. El estudio se realizó bajo el método cualitativo, del tipo descriptivo, para la asignatura de Máquinas Hidráulicas de la carrera de Ingeniería Mecánica Eléctrica, contándose con una muestra de 28 estudiantes. Posterior a la aplicación del instrumento de evaluación el estudiantado reportó sentirse feliz, alegre, haber socializado e interactuado como hacía mucho tiempo no sucedía con sus compañeros de aula, haber reducido el estrés que les genera la asignatura y haber aprendido en forma activa y más fácilmente los temas.



Gamificación, habilidades blandas, ambientes de aprendizaje

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1. Introduction

The application of the gamification technique brings benefits in many aspects among people who participate in this type of activities regardless of the environment in which they develop, noting that motivation and positive attitude towards the role that corresponds to them to develop in their social, work, educational or family environment benefit when exposed to recreational activities, reporting the literature in different studies that joy and good attitude prevail.

Based on the above, it was proposed that the integrative project to be carried out by students in the sixth grade of INME (Electrical Mechanical Engineering) as part of their evaluation process should be done with the support of gamification, for which the students were organised into teams of 4 members with the aim of developing a traditional educational toy to actively participate in the class session that would be called Science Fair.

The first objective was to plan the development of their didactic toy, which was randomly assigned and from this, they had to make a review to identify how to approach with it the relevant topics of the subject that will be evaluated through this activity. They had 2 weeks to develop their game. Subsequently, the students had to bring their game to the classroom already completely elaborated including its respective instructions to use it and socialise it with their classmates through the game in the work session called 'Science Fair'.

In this way the students had the opportunity to play with the different games built by their classmates, competing with each other and/or collaborating with their classmates to interact and learn the relevant topics of the subject through the different games in a more meaningful way, in teams and even by discovery.

2. Basis of the project

2.1 Literature review

Gamification is 'the integration of game design elements into non-game contexts has emerged as an important approach in various fields, including education and training'.

Where elements such as point harvesting, badges, missions and challenges can be used to motivate and engage users, thus improving their experience and performance', according to Di Nardo, V. Fino, R.; Fiore, M.; Mignogna, G.; Mongiello, M. Simeone, G. (2024) and is nowadays often applied in very different contexts and work environments in order to positively stimulate people.

'It is understood as a product of culture, and it can be affirmed that by playing we learn, that is why it is important to recover the intrinsic value that play has for the development of representative possibilities, imagination, communication and understanding of reality' Domínguez Mónica¸ Fiameni Claudia, Neffen Irene; Hachuel Cristina (2020). For this reason, it is affirmed that the presence of play in the teaching-learning process is of utmost importance, since it is through a set of playful activities that students learn from childhood, interrelate with their peers and achieve better performance and socialisation among themselves.

From the perspective of higher education, it is important to understand that by implementing playful strategies in the classroom, the lecture does not lose its scientific rigour or its quality. Another important aspect is that it is not a waste of time, since a good part of the teaching staff is clear that time is pressing in order to cover the subject programmes in the time allotted for this and they have the idea that if they dedicate time to generate playful activities in the classroom, it will be difficult to cover the assigned programme content and the students will end up with gaps in their educational process.

However, Domínguez Mónica¸ Fiameni Claudia, Neffen Irene, Hachuel Cristina (2020) point out that 'the protagonism of the students as experts in the art of "playing" must be recovered and empowered so that they can share the playful experiences lived at home and bring them to the classroom', applying the knowledge learnt since childhood to science so that in this way, knowledge can be enhanced and flow in a natural way, playing among classmates and in this way knowledge is built, favouring the better development of some of the soft skills necessary for the future engineering graduate.

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DOI: https://doi.org/10.35429/JBE.2024.8.19.6.1.8

The range of games is very broad and may include traditional games, symbolic games, theatrical games, construction games, technological games and mathematical games in their different formats. The main objective will be to give students the challenge of building or modifying a game and then testing it in the classroom and generating their own conclusions. Soft skills are highly desired competences in most companies that have the need to train and strengthen their staff, especially at executive or managerial levels, in order to achieve the objectives of their organisational strategy and among them leadership, emotional intelligence, assertive communication and teamwork stand out as highly desired soft skills (Liliana, 2020) cited by Sáez Meza S., and Gómez González D. (2022).

2.2 Project objectives

The general objective is to design and build a traditional educational toy that allows students to understand and apply key knowledge of hydraulic pumps, their components and applications.

The particular objectives are:

To design and build a traditional didactic game whose theme should be in reference to the first two chapters of hydraulic pumps.

To identify whether the use of gamification promotes soft skills in engineering students.

To find out how students feel about participating in an activity of this nature.

3. Methodology

3.1 Description of the methodology

The research presented is qualitative, with a descriptive scope, and an 'action-research' design based on the paradigm of learning through discovery by J. Bruner, who points out that 'importance is given to the direct action of learners on their environment...' according to Ubillús J. *et al*. (2020, p. 53) and that direct observation is used as a data collection technique, which 'includes all forms of field research, in immediate contact with reality.

For data collection, a closed questionnaire was prepared which consisted of a predetermined set of questions designed by the researcher, from which the study subjects, grouped in teams, answered through a Google forms form. In order to delimit the answers, a Likert scale with 5 response options was used: Strongly Disagree, Partially Disagree, Indifferent, Partially Agree and Strongly Agree. In this way, a systematic and comprehensive process was achieved with delimitation of the topics addressed, according to Cadena Iniguez P., Rendón-Medel R., Aguilar-Ávila G., Salinas-Cruz E., *et al*. (2017: p. 1613).

An open-ended question was also considered to allow learners to express their feelings regarding the use of gamification to present their integrative activity and the feelings that this experience generated for them. Subsequently, all the results were grouped with the support of Excel for analysis and discussion through Figures where they speak for themselves of the results obtained.

The validation of the instrument was carried out by means of an expert judgement where 3 professors with recognised experience in the area of Hydraulic Machines were given the task of evaluating each of the items and adjusting them where necessary.

The target population for this research consisted of a sample of 25 men and 3 women who took the Hydraulic Machines subject in the 2024-B calendar of the INME degree course, grouped into 8 teams of between three and four members.

The 'sample saturation' is fulfilled according to the equation proposed by Kvale S. (2011, p. 71) because according to the criteria established by the author, the sample must fall within the range of 15±10 interviewed subjects, therefore it is established that the sample selected for this research largely complies with the upper limit, in addition the author adds that from this limit the answers become repetitive so there is no need to involve more elements in the sample.

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3.2 Research questions

The following research questions were used.

1. Is it relevant that students in higher education can learn with traditional didactic games as children do in primary education?

2. How important is it for higher education and engineering students to work on integrative team projects with a gamification approach?

3. What kind of soft skills are promoted through the collaborative participation of students when building a didactic team and subsequently interacting among all classmates to try to learn about the subject in question?

4. How valuable is it to work on some topics in engineering subjects with equipment construction projects and didactic materials such as those made for this 'Science Fair'?

3.3 Hypothesis

The development of the integrative project for the subject of Hydraulic Machines where students are given the opportunity to design or adapt and build a traditional didactic toy to address the topics of classification and characteristics of hydraulic pumps, which should be able to promote active and meaningful learning in the students, leading them to experience a new integral learning experience in higher education and promoting the development of the soft skills that the syllabus indicates.

4. Results

The most significant results obtained in the Likert scale questionnaire are presented and interpreted in the form of a figure for quick analysis.

1. Do you think that Engineering students develop effective communication skills through interaction with other players in board games adapted to the subject such as lottery, Scrabble or any other?

Box 1

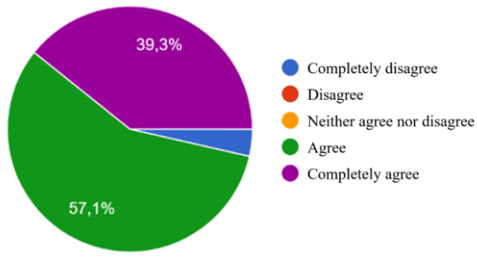

Figure 1
Developing communication skills

96.4% of students develop their communication skills through interaction with their classmates and the medium for doing so is a didactic game.

2. According to your opinion, do you consider that the quick feedback mechanisms incorporated in some board games such as Jenga, lottery, memorama, etc., help students to develop decision-making skills under pressure?

Box 2

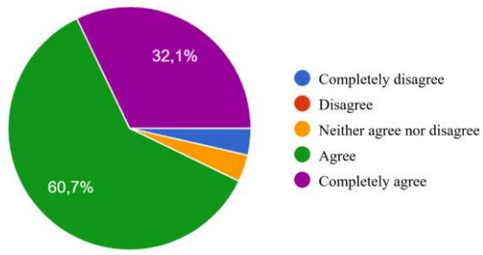

Figure 2
Developing decision-making skills under pressure

92.8% of respondents agree that playing some traditional games helps them develop decision-making skills under pressure.

3. Do you think that some of the board games, adapted to the subject of Hydraulic Machines, can influence in any way the students to improve their ability to solve complex problems, an essential skill in Engineering?

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Box 3

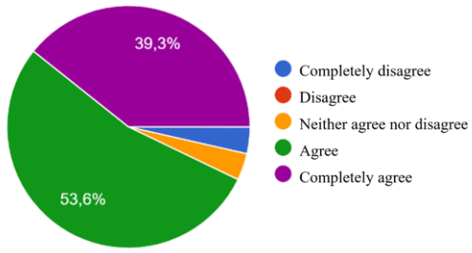

Figure 3

Improving the ability to solve complex problems

92.9% of the sample indicate that playing board games can somehow help them develop complex problem solving skills.

4. Which of the board games (of all the ones you know) would be a good example to improve complex problem solving? List one if it is the case:

Box 4

Table 1

Games to improve complex problem solving in engineering

Game	**Mentions**
Scrabble	**4**
Chess	**2**
Memorama	**4**
3D Puzzle	**3**
Crosswords	**7**

5. Do you think that by using various traditional board games adapted to engineering subjects, can these be integrated into teaching to improve collaboration and teamwork among students?

Box 5

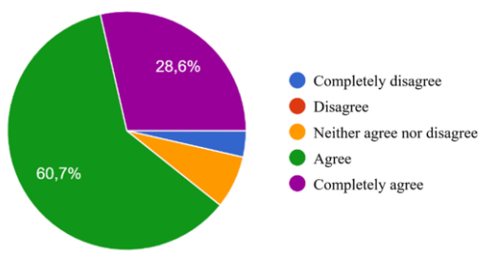

Figure 4

Improving teamwork

89.3% of students consider that it promotes collaboration between peers and teamwork.

6. Can board games such as memorama, scrabble, puzzles, "guess who", among others, strengthen the skills of analysis and synthesis of important information in the resolution of technical problems?

Box 6

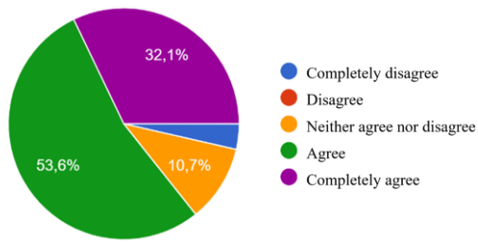

Figure 5

Strengthens information analysis and synthesis skills

85.7% of students consider that traditional games such as scrabble, jigsaw puzzles, among others, strengthen the skills of analysis and synthesis of information.

7. In your opinion, how much can the use of games such as snakes and ladders, lottery, Jenga, etc., help students develop resilience to failure, a critical skill in engineering environments?

Box 7

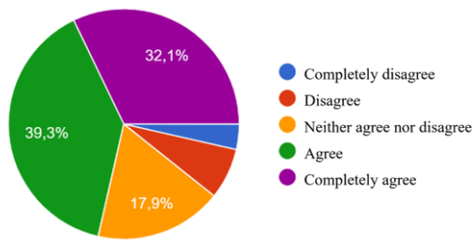

Figure 6

Develop resilience in the face of failure

Students widely consider that the use of games can significantly aid the development of resilience, a critical skill in engineering environments.

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8. In your opinion: Do you think that the use of gamification in the classroom and its competition component in traditional games can be used to motivate engineering students to learn complex and abstract concepts?

Box 8

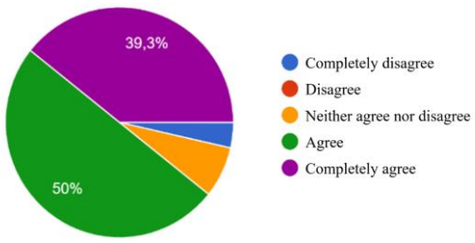

Figure 7
Motivates to learn complex and abstract concepts

According to the figure, 89.3% of the students consider that by playing traditional games they can learn complex and abstract engineering concepts, and they consider that the ideal games for this purpose are memorama, guess who, scrabble adapted to the engineering environment, among others.

9. How important do you think it is that traditional games can be modified to include engineering scenarios that promote creativity and critical thinking?

Box 9

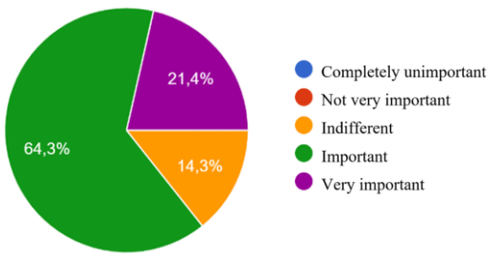

Figure 8
Promotes creativity and critical thinking

10. In your opinion, how much do you agree with the statement "The various board games adapted to the subject can help students develop important skills such as planning and resource management for engineering practice"?

Box 10

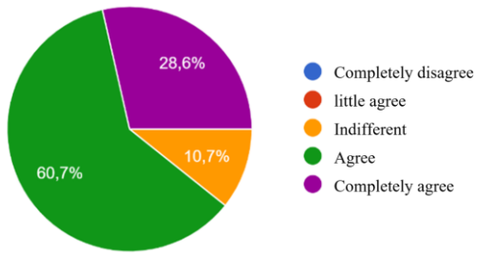

Figure 9
Developing planning skills in engineering

11. Do you think it is important for teachers to incorporate play activities that focus on the contents of your subjects in regular classes during the semester?

Box 11

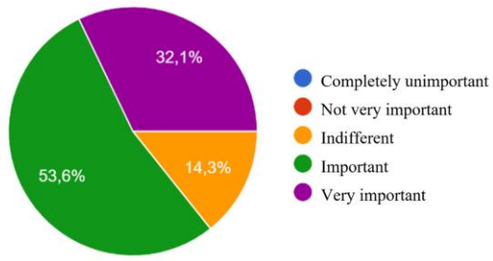

Figure 10
Importance of incorporating play activities with classroom content

12. According to your perception: How much do you consider that learning certain theoretical subjects of the subjects is improved if you learn by playing with them?

Box 12

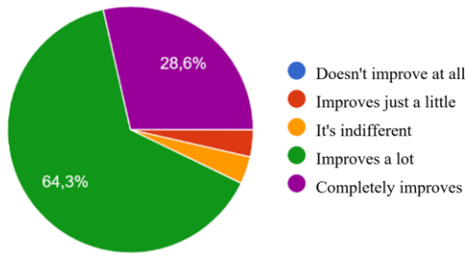

Figure 11
Enhancing learning

13. How many times in the different subjects of the course have you been allowed to play with the syllabus contents through traditional play activities?

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Box 13

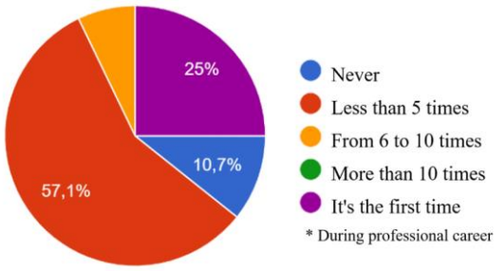

Figure 12

Number of times of traditional play activities in classes

14. How many times in the different subjects of the degree course have you been allowed to play with the programme contents through playful activities with electronic media such as Kahoot, Thynker, quiz game or any other?

Box 14

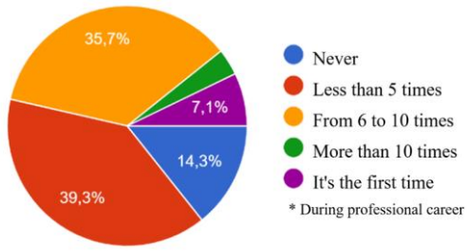

Figure 13

Number of times of electronic play activities in classes

Figure 14 shows the feelings generated by the use of gamification as an activity in and out of the classroom at undergraduate level.

Box 15

Figure 14

Feelings about the use of games in the classroom

Conclusions

89.3% of the students indicated that the use of games helped them to improve activity planning and resource management, 85.8% indicated that this type of activity helps them to improve their creativity and critical thinking and 92.8% said that it helps them to make decisions under pressure. Therefore, it is concluded that the use of traditional games in the classroom focused on the subject favours the development of soft skills among engineering students and makes them happy.

According to the students all games are good for learning Hydraulic Machines, but it will depend on the feedback given to each answer.

We believe that participation in unconventional activities inside and outside the classroom arouses great enthusiasm and motivation, as they allow students to apply knowledge in a practical way and in challenging scenarios.

Statements

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Zamora Laura. Project design, implementation, analysis and management.

María del Sol Vázquez de León. Design, implementation and analysis of questions.

García J. Marcos. Design of the general structure of the article. Revision and final adjustment. Verification of results obtained.

María Magdalena Sánchez Huerta. Design, implementation and analysis of questions.

Availability of data and materials

All the results that are obtained are in the article and can be accessed freely depending on the journal's policies.

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Abbreviations

INME	Mechanical Electrical Engineering

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Background

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Basics

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Di Nardo, V.; Fino, R.; Fiore, M.; Mignogna, G.; Mongiello, M.; Simeone, G. Usage of Gamification Techniques in Software Engineering Education and Training: A Systematic Review. Computers 2024, 13, 196.

Domínguez Mónica¸ Fiameni Claudia, Neffen Irene; Hachuel Cristina; Hilando juegos en el vaivén de un tiempo no apurado (2020).

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Article

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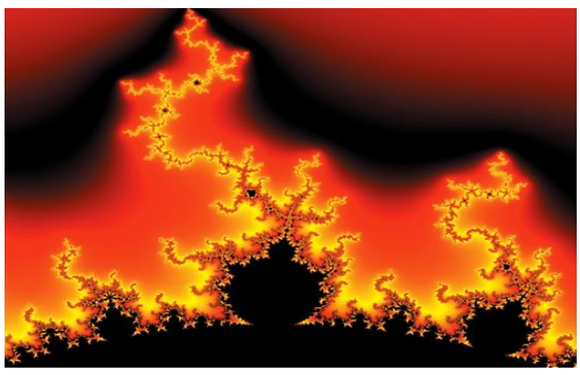

Figure 1

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Table 1

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The maximum number of Boxes is 10 items

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$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \quad [1]$$

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Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Conclusions

Clearly explain the results and possibilities of improvement.

Annexes

Tables and adequate sources.

The international standard is 7 pages minimum and 14 pages maximum.

Declarations

Conflict of interest

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Author contribution

Specify the contribution of each researcher in each of the points developed in this research.

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Benoit-Pauleter, Gerard: Contributed to the project idea, research method and technique.

Availability of data and materials

Indicate the availability of the data obtained in this research.

Funding

Indicate if the research received some financing.

Acknowledgements

Indicate if they were financed by any institution, University or company.

Abbreviations

List abbreviations in alphabetical order.

Prot-

ANN	Artificial Neural Network

References

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