

Volume 9, Issue 20 – e2025920 January – December - 2025

ISSN 2523-2495

Journal University Management

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Journal University Management,

Volume 9, Issue 20: e2025920 January – December 2025, is a Continuous publication -ECORFAN-Peru. La Raza Av. 1047 No.-Santa Ana, Cusco. Peru. Postcode: 11500, WEB: www.ecorfan.org/republicofperu, revista@ecorfan.org. Editor in Chief: Guzmán - Hurtado, Juan Luis. PhD. ISSN-2523-2495. Responsible for the latest update of this number ECORFAN Computer Unit. Escamilla-Bouchán, Imelda. PhD. Luna Soto, Vladimir. PhD. La Raza Av. 1047 No.-Santa Ana, Cusco-Peru. Postcode: 11500 last updated December 30, 2025.

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Journal University Management

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Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Social Sciences, in Subdisciplines University school management, management of university academic counseling, elements and conditions for reform in university school management, specific management models for each university context, inclusion as a fundamental tool for attending university diversity.

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Presentation of Content

In the first article we present, *Playful spaces, space for emotions* by Nieves-Chávez, Mayra Araceli & Muñoz-Serna, Beatriz Elena, with adscription in the Universidad Autónoma de Querétaro, as the following article we present, *The trajectory of SNII women at the San Martín Texmelucan Higher Technological Institute. The dispute over social reproduction work in the public and private spheres* by Soto-Rivas, Soledad, Hernández-Hernández, María Elena and Irigoyen-Arroyo, Luis Ernesto, with adscription in the Tecnológico Nacional de México Campus San Martín Texmelucan, as the following article we present, *Technological acceptance of the use of AI tools by Mechatronic Engineering students at the UTD* by García-Arámbula, Cintia Germania, Beltrán-Zhizhko, Gali Aleksandra, Marrufo, Luis Fernando and Herrera-González, Raúl Iván, with adscription in the Universidad Tecnológica de Durango, as the following article we present, *Durango 2024 learning assessment results. Statistical analysis of the mathematics area* by Díaz-Ledezma, José de la Cruz, Lino Gamiño, Juan Alfredo and Torres-Gutiérrez, Arturo, with adscription in the Instituto Educativo Dolores del Río, Universidad de Colima and Universidad Internacional de la Rioja, as the following article we present, *Bridges to STEAM: Effects of a micro-intervention on self-efficacy and gender stereotypes among female students in technical Upper-Secondary Education* by Corral-Verdugo, Alex, Jiménez-López, Eusebio, Sepúlveda-Romo, Adrián and Lilia Zulema Gaytán Martínez, with adscription in the Universidad Tecnológica del Sur de Sonora, Universidad La Salle Noroeste and Instituto Tecnológico Superior de Cajeme, as the following article we present, *Analysis of higher education teachers' messages in a virtual forum about learning models* by Alatorre-Rojo, Elba Patricia, Pacheco-Cortés, Adriana Margarita and Galindo-González, Leticia, with adscription in the Universidad de Guadalajara, as the last article we present, *University internationalization in Mexico: Comparative analysis between physical and virtual student mobility through COIL strategies and mirror classes at a public university* by Alcocer-Martínez, Fidel Ramón, Quijano-García, Román Alberto, Guillermo-Chuc, Giselle and Bernés-Salazar, Jimena, with adscription in the Universidad Autónoma de Campeche.





Content





Article	Page
Playful spaces, space for emotions Nieves-Chávez, Mayra Araceli & Muñoz-Serna, Beatriz Elena <i>Universidad Autónoma de Querétaro</i>	1-8
The trajectory of SNII women at the San Martín Texmelucan Higher Technological Institute. The dispute over social reproduction work in the public and private spheres Soto-Rivas, Soledad, Hernández-Hernández, María Elena and Irigoyen-Arroyo, Luis Ernesto <i>Tecnológico Nacional de México Campus San Martín Texmelucan</i>	1-15
Technological acceptance of the use of AI tools by Mechatronic Engineering students at the UTD García-Arámbula, Cintia Germania, Beltrán-Zhizhko, Gali Aleksandra, Marrufo, Luis Fernando and Herrera-González, Raúl Iván <i>Universidad Tecnológica de Durango</i>	1-8
Durango 2024 learning assessment results. Statistical analysis of the mathematics area Díaz-Ledezma, José de la Cruz, Lino Gamiño, Juan Alfredo and Torres-Gutiérrez, Arturo <i>Instituto Educativo Dolores del Río</i> <i>Universidad de Colima</i> <i>Universidad Internacional de la Rioja</i>	1-10
Bridges to STEAM: Effects of a micro-intervention on self-efficacy and gender stereotypes among female students in technical Upper-Secondary Education Corral-Verdugo, Alex, Jiménez-López, Eusebio, Sepúlveda-Romo, Adrián and Lilia Zulema Gaytán Martínez <i>Universidad Tecnológica del Sur de Sonora</i> <i>Universidad La Salle Noroeste</i> <i>Instituto Tecnológico Superior de Cajeme</i>	1-16
Analysis of higher education teachers' messages in a virtual forum about learning models Alatorre-Rojo, Elba Patricia, Pacheco-Cortés, Adriana Margarita and Galindo-González, Leticia <i>Universidad de Guadalajara</i>	1-9
University internationalization in Mexico: Comparative analysis between physical and virtual student mobility through COIL strategies and mirror classes at a public university Alcocer-Martínez, Fidel Ramón, Quijano-García, Román Alberto, Guillermo-Chuc, Giselle and Bernés-Salazar, Jimena <i>Universidad Autónoma de Campeche</i>	1-8

Playful spaces, space for emotions

Espacios lúdicos, espacio de emociones

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Classification:

Area: Humanities and Behavioral Sciences

Field: Pedagogy

Discipline: Organization and planning of education

Subdiscipline: Development of subjects

 <https://doi.org/10.35429/JUM.2025.9.20.1.1.8>

History of the article:

Received: January 19, 2025

Accepted: November 10, 2025

*  [\[bety.munoz@uaq.mx\]](mailto:bety.munoz@uaq.mx)

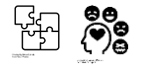




Abstract




This study unfolds through a pedagogical experience conducted in a space dedicated to playful activities, aiming to analyze the emotions generated by this space. The objective of this research is to understand the emotions evoked by the playful space, referred to as the "bubble." The space was conceived as a place that could help improve the students' social conditions and explore how play practices could contribute to emotional management and enhanced resilience. A phenomenological and hermeneutic methodology was employed for analyzing the collected data, which was gathered through a questionnaire administered via interviews. Preliminary results indicate that the students expressed emotions of joy, happiness, fun, and confidence.

Resumen

El presente trabajo se desarrolla a través de una experiencia pedagógica, la cual se desarrolla en un espacio en el que se llevan a cabo actividades lúdicas, tratando de analizar las emociones que genera ese espacio. El objetivo de esta investigación es conocer qué emociones genera el espacio lúdico, llamado burbuja. Se pensó en el espacio cómo un lugar que podría ayudar a mejorar sus condiciones sociales y cómo las prácticas de juego podrían contribuir a una gestión de las emociones y a mejorar su resiliencia. La metodología fue de carácter fenomenológico y hermenéutico para el análisis de la información recabada, la cual fue realizada a través de un cuestionario a través de entrevistas. Los resultados previos muestran que los estudiantes expresan emociones de alegría, felicidad, diversión y confianza.

Playful spaces, space for emotions		
Objective	Methodology	Contribution
To understand what emotions the play space, called the bubble, generates	A phenomenological and hermeneutic methodology was employed for analyzing the collected data, which was gathered through a questionnaire administered via interviews	Recognizing that play spaces help manage emotions and therefore strengthen resilience in students
		

Games, Playfull and emotions

Espacios lúdicos, espacio de emociones		
Objetivo	Metodología	Contribución
Conocer qué emociones genera el espacio lúdico, llamado burbuja	La metodología fue de carácter fenomenológico y hermenéutico para el análisis de la información recabada, la cual fue realizada a través de un cuestionario a través de entrevistas.	Reconocer que los espacios lúdicos ayudan a gestionar las emociones y por ende fortalece la resiliencia en las y los estudiantes.
		

Juego, Lúdica y emociones

Area: Promotion of frontier research and basic science in all fields of knowledge

Citation: Nieves-Chávez, Mayra Araceli & Muñoz-Serna, Beatriz Elena. [2025]. Playful spaces, space for emotions. Journal University Management. 9 [20]1-8: e1920108.



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Introduction

In classrooms, there are not only concerns about teaching methods or learning rhythms, but also social and emotional issues. Classrooms are mirrors of macrosocial realities; they are the place where previous socializations converge. One of these realities that seeps into classrooms is the various forms of tense relationships, such as hostile glances, whispering, not greeting each other, placing backpacks next to chairs to isolate oneself from others. These conditions are a call to the task of educating, because they need to be humanized.

As a result of the above, this led to the idea that play could help improve social conditions, and certain play practices contributed to this. From there, the decision was made to go further and create a playful space for constant work. Situations continued to arise that prevented free play from flowing, with expressions such as: ‘we have history’, meaning that they have experienced aggression and emotional distancing, as well as an idea of internal competition: ‘I have to earn my place and be the best’, ‘I’m tired of helping my classmates, they won’t let me get ahead’. Added to the above are social context conditions, such as the use of screens, ‘I’m afraid to be myself, what if someone is recording me and uploading it to the internet?’ In an environment of insecurity and lack of smoothness, it is not possible to build playful, loving and congratulatory spaces; there will always be reserve in being genuine, although there will always be a presence of diverse emotions.

As can be seen in the above lines, the management of emotions in university students is still in development, and it is still difficult for them to manage them. To help develop emotions, self-knowledge is required, but above all, self-recognition of those emotions that become thick, that is, recognition of how the body expresses those emotions, in order to subsequently achieve emotion management. It is also necessary to know that emotions will always be present, at every moment of the day and in the different spaces in which we live.

In order to achieve continuity in the management of emotions, the aim was to create an environment of trust and free expression through play and art.

The first step was to build a safe place where there is no fear of being, but also the confidence to be contained and to contain, and even more so to be in a place to be happy. The objective was a playful space to experience emotions for the construction of emotional bonds. For Bauman [2002 and 2010], this is a time when social structures that do not provide support for people to relate to others with love are weakening, as insecurity, uncertainty and mistrust in proximity to others are experienced [Bauman and Donskis, 2015], leading to a loss of tenderness and giving way to scenarios of violence, indifference and little social commitment. How can a playful space contribute to loving relationships in the classroom? The creation of a playful space implies a territory to be inhabited from a playful and emotional perspective, from imagination, collaboration, festive encounters and loving treatment.

For this study, a theoretical framework was constructed that recovered the central idea of what a playful space is and its link to emotions. The playful space was conceptualised as an intentional space that transcends the physical to encourage play, enjoyment and encounter. The playful space is a constant construction that fosters rootedness, expression of emotions and social learning.

The methodological study described, which was phenomenological and hermeneutic in nature, sought to experience this playful space in order to observe and describe the emotions triggered. Through techniques such as participant observation, field notes and interviews, the subjective experiences of the participants were recovered. The results highlight that play allows emotions to surface and be managed, fosters resilience and creates emotional bonds through tenderness, which is crucial even in university education to train emotionally competent professionals.

Background

The experience of being in school spaces, such as the classroom, has a meaning in itself: a square, inflexible design, specific furniture for teaching and learning activities, and an arrangement that allows for the development of classes. Proposing a different space implies reconfiguring school spaces.

The construction of a playful space is not only the physical space, but also the meaning it takes on day by day; hence it is a constant process, a yes sustained in time and space, a commitment to be there based on trust, which in turn allows the development of social, cognitive and emotional skills that enable one to be and exist in the world. The play space is not only a question of attitude, a desire to be, but also of feeling rooted and belonging to a physical place that allows for the deployment of specific practices.

The play space is an intentional space that is set up to encourage play among its participants. It is a place with toys, games and furniture [Moreno, 2012] available to invite enjoyment and interaction. This invites us to redefine the space, to inhabit it with joy, to give it a different meaning in life and to create an idea of a happy world, which means taking a leap into fun and allowing ourselves to feel emotions.

According to research carried out by Bowen, Bravo, Delgado, Pico and Sánchez [2025, p. 498] the implementation of playful activities in the classroom has a positive effect on the development of emotional intelligence, since through a series of playful activities, students are able to identify their emotions, as well as manage sadness or anger, and make decisions under a scheme of balanced emotions through reflective thinking. Therefore, the use of playful activities in the classroom is a viable strategy for achieving different pedagogical objectives, but also for training citizens with the ability to manage their emotions and thus interact in a healthy and positive way.

Muñoz [2024, p. 167] comments that emotional intelligence refers to feelings and emotions in human beings, which have universal forms of expression, and it is through the experience of play that these emotions and feelings are expressed naturally. Buitrago [2021, p. 5] defines feelings as lasting emotional states, while emotions are defined as immediate responses to the environment. This is where playfulness plays its greatest role, as the emotions expressed during play are natural expressions at their finest. Emotional intelligence is precisely the ability to control, understand and identify our feelings and emotions, recognising them in others and directing and balancing them, according to Jurado [2009, p. 1].

Consequently, emotional intelligence not only allows us to manage our emotions but also to recognize them in the people we interact with, which enables a healthy and open relationship with others.

It is necessary to make a digression with regard to the culture of the school space. The playful space is made possible by reinterpreting a space through play and emotion, creating and expressing what lies within, discovering new abilities and skills. Iuri and Villafuerte [2022] argue that experience produces a benefit in intellectual development and understanding of the world, because it helps to distance oneself from culture and imagine new horizons. It also produces emotions that provoke pleasant sensations, leading to immersion in play, that is, a process of questioning the world for its order, seeking answers, as well as giving free rein to one's emotions. Play makes it possible to construct new meanings of life, new ways of communicating the inner world through love and tenderness.

Emotional intelligence is a concept developed by Salovey and Mayer, who coin this concept as a way of controlling and regulating one's own feelings and those of others in order to master thought and behaviour. [Correa, 2021]. Human beings are, by nature, emotions and feelings from the moment they are born. Emotions are universal expressions of how human beings feel and, of course, of recognizing emotions in others.

This allows for the development of empathy, the management of one's own emotions and the development of those emotions. Emotional intelligence develops mainly from the early stages of life, but it is important that it continues to develop throughout life. However, there is a belief that, in university education, emotional intelligence should not be worked on in the classroom and that students arrive at educational institutions with all the necessary skills.

But the reality is that even at university level, it is necessary to continue supporting students in the development of their emotional intelligence, because this allows them to adapt authentically, overcoming different adversities and difficulties, while at the same time learning from experience, all of which is reflected in their resilience.

The development of students' emotions also takes place in the classroom, through academic activities themselves and, of course, through the various educational activities carried out in the classroom. From the theoretical proposal of emotional intelligence, progress is made in the development of different skills that go hand in hand with it, such as social and emotional development, as it contributes to the way people relate to each other; and cognitive development, because it allows students to develop their critical thinking and creativity. Being able to manage emotions allows each individual to achieve positive mental health that helps them deal maturely with the different situations they face throughout their lives. And, of course, we cannot forget learning, as this occurs naturally when the emotions generated are positive, giving way to natural learning.

Nieves, Muñoz and Hernández [2024, p. 41] comment that play is about committing to containing impulses or managing negative emotions and, through reason, being in control of oneself; it is about assuming an "as if" attitude based on emotion and reason, suspending that which separates. In the same way, playfulness allows emotions to be shown, but at the same time, it allows those that are not part of the game to be contained. In other words, it allows for the management of one's own emotions in order to continue developing skills in the way they relate to others. This involves an act of resilience, which most often manifests itself as an obstacle in different playful activities and within the classroom. Acuña emphasizes the importance of continuing to develop emotion management throughout the university professionalization process, as shown in the following lines:

Among the factors involved in a student having a high level of resilience to face the challenges encountered during their professional training is emotional intelligence, which is known as a person's ability to recognize their own emotions, recognize the emotions of others, express their emotions appropriately, and discriminate between the positive, negative, sincere, and hypocritical emotions of others. In other words, when one has adequate emotional intelligence, one can cope with adverse situations and find the most assertive ways to overcome difficulties. [Acuña *et al* 2021, p. 3].

Continuing to develop emotional intelligence in university students is of utmost importance, because its development has an impact on their personal and social lives and on their future when they enter the workforce. Playfulness plays an important role in this area, because it has an impact on both their learning of the subject matter and on their interaction with the group and with the rest of society. Playfulness allows emotions to surface that are often suppressed in academic and training spaces. On the other hand, if these types of activities are not carried out, the training of future professionals is compromised, without considering that they will also work with people in their future work environment.

Methodology

The main objective was to experience a playful space for the experience and recognition of emotions, with the aim of encountering others with tenderness and triggering positive emotions. The research sought to observe and describe the forms of play and emotions experienced, based on the meaning given to each of the playful activities and their emotions [Schwartz, 2006]. The research was non-experimental and descriptive in nature because the immediate context of play was observed for the description and analysis of the phenomenon, based on the genuine expressions of what triggers the playful encounter, in order to understand what emotions the space generates.

In order to study the experiences from the perspective of emotional intelligence theory, it was necessary to use phenomenological and hermeneutic methods as a way of recovering, describing and interpreting the subjective experience of enjoyment and the recognition of emotions. Investigating the experience of play as a moment of multiple emotions and identifying the internal factors that give meaning to that moment of existence and that can be extended to everyday life can be approached from phenomenology, a method that brings to light and shows the person from their subjectivity [Heidegger, 2014].

In a second stage, work was done to understand these experiences. To do this, it is necessary to reorganize the experiences and understand how the subject assimilated them in their daily life.

Heidegger [2014] mentions that interpretation consists of perceiving how something is as something, explaining the purpose of things in their development for projection into the world. Recovering the life experience involved recovering those things or situations that limit or diminish existence, as well as those that enhance the emotional encounter, from emotions, ways of naming oneself in the world, and what makes one enjoy the encounter with the other.

Methods, techniques, and instruments

emotions of pleasure or displeasure in life, which limit one from being what one desires. The aim of the interview was for the person to give a biographical account of themselves, recounting their life experiences, those moments they consider most significant [Moriña, 2017], the emotions they generate, and what it meant to them to hear stories and the lessons they learned from these experiences.

Internal participant observation invited them to take on the role of another player in the activities to share joys and fears and to live the moment in an empathetic and committed way. This allows students to continue developing the management of their emotions and, of course, the recognition of them in themselves and in others. At other times, I was an external observer, without inferring or modifying the experiences of describing and recording how the session unfolded [Girardi, 2011].

The field diary was used as a tool for recording experiences in the play space. Another research technique was the interview, which allowed them to use their own voice to express fears, anger, confusion, as well as longings, hopes and desires. The aim of these experiences was to recognise situations that limit and enrich the emotional bond.

Ethical considerations

This project is based on safeguarding human dignity, for which voluntary consent is essential, and was therefore provided to all participating students.

Results

La Burbuja: a playful space

A playful space is one that invites play and happy moments, and this is what characterizes La Burbuja, because what it has awakened in the students is a space for play and enjoyment, from the physical space itself to the experiences that take place there. 'A space with cheerful colours, with plenty of things to do, which is open to creativity,' it is a space that invites you to leave the seriousness of the classroom behind and enter a time when anything is possible through creativity. La Burbuja has a set-up of spaces and games that can provide students with a moment of motor movement through dancing, or an exercise in imagination to paint a mural or become a city builder through a board game. It is a space that triggers multiple alternatives in proportion to the different personalities of the students, who become potential players in the playful space through the imagination and creativity brought into play.

The play space fulfils its purpose by awakening the desire to play, creating an atmosphere that invites encounter and a feeling of freedom. The space awakens the intrinsic well-being of sharing and coexisting with others, strengthening the idea of being a group. When spontaneous laughter is encouraged, it becomes a channel for releasing tension and expressing emotions in a genuine way. Joy becomes a common language that opens channels for communication and cooperation. The play space fulfils its task when play ceases to be a mere activity and becomes a meaningful experience of human encounter.

Emotions in the bubble

The results show a variety of emotions in their different stages, which are shown below

1. Responsibility for managing the bubble

Most of the time, when you take responsibility for something, such as managing the bubble, which involves administering it, cleaning it before and after carrying out activities, organizing materials and seeing what else can be incorporated to make the experience enriching, as well as organizing with colleagues who are invited to the space itself, management skills are required.

Nieves-Chávez, Mayra Araceli & Muñoz-Serna, Beatriz Elena. [2025]. Playful spaces, space for emotions. Journal University Management. 9 [20] 1-8: e1920108. <https://doi.org/10.35429/JUM.2025.9.20.1.1.8>

This entails a responsibility that generates different types of emotions, from fear and anxiety, which is triggered by decision-making and, at other times, by not feeling confident that one has the necessary skills for its administration. Similarly, students are pursuing a degree in management, which involves organizing activity spaces, materials and, above all, human capital management, which goes hand in hand with the aim of enjoying recreational experiences in a specific space. In turn, they report feeling very happy and cheerful.

2. Upon entering and remaining in the bubble

The students refer to entering the bubble as a feeling of happiness and tranquillity, as they know it will be a space where they can leave behind the stress and anxiety that comes with studying for a profession. Other students report feeling calm, joyful, and loving, as well as enthusiastic because they know they will have a peaceful and fun time. Similarly, what triggers all these positive feelings is that they consider it a space where they can leave stress and anxiety behind and enjoy themselves as friends, which they also value as a space where they can release all their academic stress. The bubble space, through play, allows them to be open to creativity, feeling free and unrestricted, even being able to laugh without feeling ashamed and, of course, playing with their classmates.

3. Emotions after the bubble experience

The students who have participated in this playful experience in the bubble comment that after their stay in it, they feel less stressed, as being together with their friends helps them to lower their stress levels. They also say that being in the bubble makes them feel happy and relaxed, excited, cheerful, more alive and less worried, and more confident in themselves. It also generates negative feelings, such as frustration, when they see that there are people who do not take care of the space and do not really take advantage of the opportunity to experience play as a tool to reduce stress and have a good time.

4. Leaving the bubble space

In general, students comment that they feel less stressed after leaving the bubble. They comment that in this space they can relax with their friends, but there are also those who report that it is an emotional roller coaster due to the conflict caused by leaving the bubble.

They also express that having a space for play and relaxation has greatly improved the integration and relationship between group members, keeping them more united and confident as they have fun and laugh together. In turn, they say that they feel more connected, integrated and not excluded. In conclusion, the students say that the bubble is a great responsibility, not only because of the space, but also because of the satisfaction of having revived such a beautiful space that manages to spark joy and happiness.

Discussion

Play ceases to be a mere activity and becomes a meaningful experience of human encounter in a playful space, a space that evokes joy, genuine expression of emotions and the ability to build strong bonds between peers, becoming moments that enrich the emotional and social dimension of the students. The bubble is a space for play but also for the expression of emotions.

The playful space, designed for play and exploration, acts as a catalyst for emotions such as joy, surprise, enthusiasm and fun. This moment is what Moreno [2012] called emptiness, which is the release from the everyday, letting down one's guard or ceasing to be in the mode of duty. It is what allows one to experience new emotions, stimuli and sensations that give way to experiences filled with tenderness. This safe environment allows emotions such as joy to flourish spontaneously, which is essential for psychological well-being and the creation of memorable and positive experiences.

This experience of emptiness is the possibility of renewing energy, of giving oneself over to play [Moreno, 2012 and Daniela, 2016] and being able to fill oneself with the new, and that is where emotional management begins, because the playful space invites people to face challenges, rules and social interactions that naturally evoke a range of emotions, including frustration, fear or anger, and this helps emotional regulation, because playing is a kind of 'as if' and allows for the experimentation of the new. The space acts as a safe 'training ground' where it is permissible to feel and, at the same time, practise regulating these impulses to maintain the cohesion of the game, thus fostering resilience and emotional intelligence.

For Huizinga [2014], play is a kind of role-playing, and this makes the moment an empathetic encounter, because it is pleasant to be with others and the world; the playful space generates empathetic connection and encounters filled with tenderness. Both Huizinga [2014] and Moreno [2012] mention that sharing a playful experience generates emotional harmony among players.

The playful space is par excellence the expression of emotions and complicity [Jiménez, 2007]. Collective laughter, complicity in a strategy, or the open expression of emotions create a bridge of mutual understanding. This not only allows us to recognise our own emotions, but also to read and interpret those of others, strengthening empathy and emotional bonds through tenderness and trust.

As can be seen in the results, the bubble as a playful space generates positive emotions, from happiness, tranquillity, laughter and integration among the participants and members of the different groups involved in the bubble project. In this way, it can be seen that spaces of this type help young university students to continue managing their emotions and, in this way, to forge future professionals in a comprehensive manner, as future citizens of the world, with human qualities, which are necessary in these times.

Conclusions

For a recreational space to fulfil its function of bringing joy and triggering positive emotions, it needs to be appropriated and a commitment made to be an active player who uses their imagination and creativity. The recreational space is a place to be genuine.

In addition to all of the above, it can be inferred that recreational spaces, such as the bubble, have a positive impact on young undergraduate students, as they allow them to manage their emotions and strengthen their resilience in the face of the different situations they encounter in their daily lives. In this way, the recreational space can be considered a strategic tool in the training of future professionals, who will face the vicissitudes of working life, based on their experience in the classrooms of their training.

Declarations

The authors declare that there is no conflict of interest.

Authors' contributions

Mayra Araceli Nieves Chávez assisted with the fieldwork, literature review and writing of this paper.

Beatriz Elena Muñoz Serna assisted with the fieldwork, literature review and writing of this document.

Availability of information

Available with ethical restrictions.

Funding

No funding.

Acknowledgements

To the Autonomous University of Querétaro and the students who participated in this research.

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
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The trajectory of SNII women at the San Martín Texmelucan Higher Technological Institute. The dispute over social reproduction work in the public and private spheres

La trayectoria de las mujeres SNII en Instituto Tecnológico Superior de San Martín Texmelucan. La disputa del trabajo de reproducción social en el espacio público y privado

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Classification:

Area: Social Sciences
Field: Sociology
Discipline: Topical social or social problems
Subdiscipline: Gender studies and women

 <https://doi.org/10.35429/JUM.2025.9.20.2.1.15>

History of the article:

Received: June 07, 2025
Accepted: November 10, 2025

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Abstract

This article presents an analysis of the trajectory of the women members of the SNII attached to the Instituto Tecnológico Superior de San Martín Texmelucan through a qualitative methodology with a feminist perspective with the aim of making visible the academic and scientific work they carry out within a Decentralized Higher Education Institution, which is characterized by particular nuances of hiring and structural organization that exacerbate the job insecurity and hiring instability that configures the public space of science and academia.

Resumen

El presente artículo presenta un análisis de la trayectoria de las mujeres integrantes del SNII adscritas al Instituto Tecnológico Superior de San Martín Texmelucan a través de una metodología cualitativa con perspectiva feminista con la finalidad de visibilizar el trabajo académico y científico que realizan dentro de una Institución de Educación Superior Descentralizada, que es caracterizada por matices de contratación y organización estructural particulares que agudizan la precariedad laboral y la inestabilidad de contratación que configura el espacio público de la ciencia y la academia.

The trajectory of SNII women at the San Martín Texmelucan Higher Technological Institute. The dispute over social reproduction work in the public and private spheres.		
Objectives	Methodology	Contribution
Make visible the academic and scientific work carried out by women members of the SNII in the face of the disputes they experience in private spaces.	Qualitative methodology, particularly critical narrative as a possible and coherent format with the theoretical foundations of feminisms	The disputes between academic and scientific work and the reproductive work carried out in the private sphere. The representation of women in the SNII of the ITSSMT

La trayectoria de las mujeres SNII en Instituto Tecnológico Superior de San Martín Texmelucan. La disputa del trabajo de reproducción social en el espacio público y privado		
Objetivos	Metodología	Contribución
Visibilizar el trabajo académico y científico que realizan las mujeres integrantes del SNII frente a las disputas que viven en los espacios privados	Metodología de carácter cualitativo, particularmente la narrativa crítica como un formato posible y coherente con las bases teóricas de los feminismos.	Las disputas que llevan a cabo entre el trabajo académico y científico con el trabajo de reproducción llevado a cabo en el espacio privado. La representatividad de las mujeres en el SNII del ITSSMT

Researchers women, Academic Work, Social Reproduction

Investigadoras, Trabajo académico, Reproducción Social

Area: Advocacy and attention to national problems

Citation: Soto-Rivas, Soledad, Hernández-Hernández, María Elena and Irigoyen-Arroyo, Luis Ernesto. [2025]. The trajectory of SNII women at the San Martín Texmelucan Higher Technological Institute. The dispute over social reproduction work in the public and private spheres. 9 [20] 1-15: e2920115



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Peer review under the responsibility of the Scientific Committee MARVID®- in the contribution to the scientific, technological and innovation Peer Review Process through the training of Human Resources for continuity in the Critical Analysis of International Research.



Introduction

This is a qualitative study on disputes over public spaces in science and academia through the recognition of academic work within the educational projects of the ITSSMT and the social reproduction work carried out by researchers recognised by the SNII and affiliated with the Decentralised Technological Institute. This is important because it highlights the work carried out by women who work double and triple shifts in the domestic sphere and yet are researchers appointed within the science evaluation system in Mexico.

The added value is that gender studies place the subjects of study as women researchers who are protagonists in the transformation of science, since despite being less represented at the national level with a participation rate of 40% for the SNII in 2025, their performance at the ITSSMT represents a break with the so-called glass ceiling and shows that, despite being mature women, they are examples of women's historic struggle to make their presence felt in public spheres such as science and academia.

The central hypothesis is that the gender roles performed by female researchers through social reproduction work is a factor that causes greater emotional and health strain, but that despite this, at the ITSSMT, it is female researchers who are recognised in the evaluation system.

To carry out the study, the following topics are developed:

a] Description of the Decentralised Technological Institutes as the institutional space where female researchers carry out their work; b] The transformation of teaching work under neoliberalism, where productivity is rewarded and evaluation systems such as the SNII, PRODEP and ESDEPED emerge; c] The need for a gender perspective in the representativeness of the SNII to identify participatory gender quotas and analyse the viability of public policies in pursuit of equity, d] the qualitative methodology used in the interpretation of the researchers' narratives, e] interpreted results and finally g] conclusions that highlight the trajectories of teachers appointed by the SNII at the ITSSMT.

Decentralised Technological Institutes

Meza, *et al.* (2024) document that higher education in Mexico is composed of thirteen subsystems based on their legal regime or the areas of training in which they specialise. They can be classified as public or private; autonomous or state-run; universities or technological institutes or of various kinds.

It is composed of the following 13 variables: Federal public universities, State public universities, Technological universities, state public universities with solidarity support, technological institutes, polytechnic universities, the National Pedagogical University, the Open and Distance University of Mexico, intercultural universities, public research centres, public teacher training colleges, other higher education institutions that, due to their particular characteristics, cannot be placed within the above subsystems, and private higher education institutions.

Once located within the universe of higher education in Mexico, the National Technological Institute of Mexico [TECNM] is one of the main public institutions of technological higher education in Mexico, with a student enrolment of 602,954 in 2021. Its coverage represents 12.9% of higher education enrolment and, through its engineering and exact sciences profile, it trains 41% of engineers throughout the country annually.

Institutionally, the TECNM's objective is to provide higher technological education, continuing education, dual education, refresher courses, training and academic improvement, and its scope in higher and postgraduate education aims to focus on strategic sectors of the country's development. It is important to discuss the construction of academic and scientific spaces as mechanisms of power that regulate positioning and permanence in teaching work.

It is important to mention the scope of the programmes offered through the TECNM, which are: 5 higher technical degrees, 2,059 bachelor's degrees and 280 postgraduate degrees.

There are eight scientific fields in which the programmes are developed: arts and humanities; social sciences and law; administration and business; natural sciences, mathematics and statistics; information and communication technologies; engineering, manufacturing and construction; agronomy and veterinary science; and services. The former National Quality Postgraduate Programme [PNPC], now the National Postgraduate System [SNP], is divided into 105 master's degrees and 33 doctorates. In terms of the PNPC level, there are 30 consolidated programmes, 79 in development, 26 recently created and 3 of international competence. The TECNM is made up of 254 institutes, of which 126 are federal and 122 are decentralised.

In other words, decentralised technological institutes represent 48% of all technological institutes. It also has four regional development and equipment centres and two research centres. Given the structure of the TECNM, the actors involved in the goal of education as a human right include teachers, administrators, and support staff.

Technological Institutes in the State of Puebla

This section presents data on the ITFs and ITDs in the state of Puebla, their year of creation, and student enrolment for the 2024-2025 academic year. There are 17 ITs in the state of Puebla, of which 3 are ITFs [18%] and 14 are ITDs [82%]. The ITs in Puebla were founded between the early 1970s and 2007, following four decades of implementation of technological higher education in the state. Carro and Lima [2024] identify the need to reverse the established neoliberal educational model, as pointed out by Villalvazo [2016], in three stages: the post-revolutionary [1921-1940], the urban capitalist [1940-1976], and the globalisation [1976-2007] stages. The years of creation of the ITs in Puebla are used to link the nation project with the educational models and, with that, the infrastructure created.

The approach to the public university as a space for analysis identifies the importance of educational projects. Latapí [1998], cited in Carro y Lima (2024), refers to five educational projects in the 20th century: the original Vasconcelos project through rural education, the creation of the SEP in 1921;

The socialist project [1934-1946] with compulsory education; the technological and industrial project proposed in 1928 by Sáenz and continued by Cárdenas; the national unity project [1943-1958]; and the modernisation project from the 1970s onwards [Carro y Lima (2024)]. In the state of Puebla, the creation of ITs emerged in the final stage of the capitalist urban educational model and that of globalisation, as identified by Villalvazo [2016] or the so-called modernising model (Carro y Lima, 2024).

Thus, the public university is the public space where the researchers in this study carry out their academic and scientific work. The university as a public space is perhaps one of the institutions that has changed the most in its structure and organisation since the implementation of neoliberalism in Mexico in the late 1980s (Gutiérrez y Echeverría, 2023).

In particular, the ITSSMT was founded in the early 20th century in the municipality of San Martín Texmelucan, in an industrial area that evolved from an agricultural economy to an industrial and service region, as detailed in the import products of the Texmelucan region [Secretariat of Economy, 2025]. Thus, the ITSSMT emerged in response to a neoliberal education policy, founded as a decentralised public body of the state government.

Currently, ITSSMT and its teaching staff find themselves in a postmodern context described as 'innovative' by Acosta (2022). University governance, power and autonomy in the era of innovation date back to the years of educational modernisation in the 1990s, when evaluation and accreditation were placed at the centre of institutional management from the second decade of the 21st century onwards, right at the time of the COVID-19 pandemic.

Higher education institutions coexist with "information and communication technologies, the robotisation of public and private services, data science, digitisation and artificial intelligence, as well as the proliferation of boot camps, digital platforms and hubs, tools that are considered to be the causal basis of innovative processes in industry, government, public services and global trade, as well as in academic and professional training processes" (Acosta, 2022).

Transformation of academic work in globalisation

The teaching staff hired at TECNM is configured as a transforming agent that cuts across educational policies. Educational policies in globalisation create "a narrative of cultural development and educational ideology at the global level (García y Chavoya, 2014). The human capital that contributes to Article 3 of the Constitution related to education is an important part. According to TECNM reports [TECNM (2020)], for the 2020-2021 school year, there are 30,483 teachers, of whom 13,671 are classified as full-time teachers, 13,693 have postgraduate degrees [17% with doctorates, 82% with master's degrees and 1% with specialisations] and 3,478 have desirable profiles. It should be noted that academic staff are required to complete compulsory diploma courses, which include: Diploma in Tutor Training, Diploma in Teacher Training and Skills Development, Diploma in Educational Resources in Virtual Learning Environments, Comprehensive Programme for Professionalisation, Training and Updating of Digital Skills, among others that are requested. The constant credentialisation of teacher training at TECNM is characteristic of the incursion of neoliberalism into higher education [Carrasco, 2020; Ordorika, 2010]. This research aims to contribute to the debate on academic work in a neoliberal context.

Through a feminist methodology, the strategies of the SNII researchers at ITSSMT as ITD are highlighted. The narratives of the researchers allow us to situate knowledge and experiences in order to politicise the disputes or reconciliations that take place between science, capital and domestic spaces.

In the neoliberal context, academics affiliated with the SNII face conflicts in their academic and research work due to the new productivity standards required [SNII, PRODEP, ESDEPED]. Researchers are mostly responsible for unpaid reproductive work, which is devalued by societies such as Mexico's, since, although they are researchers, they are first and foremost women, and as women, they are culturally assigned domestic work. One of the main theses of this article is the complexity that exists between the public and private spaces in which women are immersed in the dichotomy of the sexual division of labour (Toledo y Aguilar, 2016).

However, the public space where academic and scientific work is carried out by women academics faces competitive neoliberal educational environments. Aboites (2010) refers to a crossroads for Latin American universities in the face of the dismantling of the principles of nationalist and welfare society that identified them in the 20th century.

Education and public universities, conceived as training grounds for the highly competitive human capital required by international corporations, face the even greater needs for knowledge generated by thirty years of dispossession and dismantling of education as a social heritage in the deeply differentiated Latin American societies (Aboites, 2010, p. 96).

Academic and research work faces the scientific productivity required by evaluation systems in terms of quantity, while globalisation as a stage of capitalism forces public institutions to compete in the major rankings, and with this, teaching staff, both women and men, take on the task of being present with the required output.

Women dedicated to science who are in ITDs, as in the case study, face the crossroads of globalisation, understood as 'a stage in the development of capitalism and a hegemonic model of capital that establishes a set of different relationships within and between state institutions'. Public institutions founded on the modernising educational model, such as the TSSMT in the study, regulate the academic work of the researchers in the study. Constant evaluations, courses and diplomas shape the training of the researchers in the study.

Higher education institutions in the neoliberal model promote the quality, competence and productivity characteristic of the hegemonic model of capitalism. The way in which Mexican public universities that carry out research face international rankings goes through what Ordorika (2006, p. 42-44) calls a 'powerful mechanism for reproducing inequalities which faces a system of value allocation'.

The way research is conducted within academia has undergone changes aimed at distinguishing scientific productivity. For Galaz *et al* (2012), members of the S.N.I.I. within the Teaching Involvement Classification - Research Classification based on productivity carried out by the highest academic degree indicates that professors who meet the levels required by the scientific evaluation system, together with the criteria of the faculty improvement programmes, face external demands to increase research.

In other words, S.N.I.I. members face greater qualification challenges than faculty hired in public institutions that do not have this distinction. However, they face social questioning as to whether their scientific productivity addresses social realities. The disputes are complex because they arise both from the configuration of the teaching profession through the historical construction of recent decades in Mexico and from the link between the social science they produce and the search for common/social welfare.

According to Estévez y Martínez (2012), there have been transformations for academics working in Mexican higher education – as is the case with the S.N.I.I. – who, in addition to working for higher education institutions, are regulated by quality assessment systems with regard to scientific productivity. For the authors, since the 1960s there has been a greater demand for teaching services.

From the perspective of Galaz, *et al* [2008], cited in Estévez y Martínez (2012, p. 372), the configuration of the role of academics in Mexico has undergone four fundamental stages: the first, known as the ‘professor’ stage, covering only hours per week and increasing their professional status; the second stage, known as the ‘teacher’ stage, lacked professional experience and, due to the expansion of university enrolment beginning in the 1970s, staff were hired who sometimes lacked a university degree; the stage emphasising the academic as a ‘researcher’, created in 1984, saw federal support within schools to carry out these functions; Finally, the stage of the ‘integral’ and “desirable” functions of the academic.

Similarly, in their study, Estévez y Martínez, when referring to the analysis of gender equality, point out that ‘women are not fewer in number, but also occupy positions of lesser importance within the institutional hierarchy’ [2012, p. 382]. However, as can be seen in the ITSSMT reports, only three women are recognised by the SNII. These reports refer to work to be recognised as teachers, academics and scientists in a neoliberal educational context.

The formation of teachers with S.N.I.I. and PRODEP profiles are desirable characteristics in a context of international competition and productivity measurement standards that are so important in the current stage of neoliberalism that it permeates the fields of research and public higher education. Public policies in education and the Mexican scientific system cannot be separated from the formation of human resources that are desirable for their ‘quality and productivity.’

The race for meritocracy rewarded in the neoliberal context is the framework of quality and productivity required by scientific evaluation systems. Public universities also meet the productivity standards required by global organisations such as the International Monetary Fund [IMF] and UNESCO, among others. Casanova y Rodríguez (2014, p. 13) point out that ‘the governance of public universities was modified by the influence of changes in belief systems, contextual transformations, and the profile of public policies.’

Other evaluation programmes have emerged in the arena of academic competition. Acosta (2014) notes that the emergence of programmes such as the Fund for the Modernisation of Higher Education [FOMES] [1991-2000], the National System of Researchers [SNII] [1984-present], the Comprehensive Institutional Strengthening Programme [PIFI] [2000-present], the Teacher Improvement Programme [PROMEP] [1998-present] and the systems of incentives for the academic performance of university professors [1994-present], ‘these funds can represent up to 17% of the total budget of universities, although the overall average is estimated at around 10%’ [Acosta 2014, p. 39].

For Navarro and Pacheco [2014, p. 84], ‘The Teaching Performance Incentive Programme is part of a policy to compensate for the low salaries received by teachers, created by the federal government and implemented in public universities.’

ESDEPED began in May 1992, in the context of the so-called modernisation of public universities, aimed at academics whose main activity is teaching. As established in the BUAP Academic Portal user manual. ESDEPED Programme ‘The federal government, seeking to promote and accelerate the process of modernisation of upper secondary and higher education, proposes a policy of incentives that emphasises the establishment of differentiated economic benefit programmes.’

At the national level, 28,601 staff members are contracted by the TECNM for the 2024-2025 period, of whom 17,865 are men [62%] and 10,736 are women [38%]. By type of contract, 14,163 teachers are full-time, representing 49.51%, 12,512 teachers are hired by the hour [43.74%], 996 teachers are part-time, representing 3.4%, and 930 teachers are hired for ¾ time [3.3%]. (TECNM, 2024).

Within the ITs in the state of Puebla, 1,538 teachers are employed, of whom 917 are men [60%] and 621 are women [40%]. By type of contract, 549 are full-time [35%], 917 are paid by the hour [60%], 40 are part-time [3%], and 32 are three-quarters time [2%] [(TECNM, 2024).

Specifically, at ITSSMT, 85 teachers were hired in 2024, of whom 41 are men [48%] and 44 are women [52%]. By type of contract, 61 teachers are hired on an hourly basis [72%] and 24 are full-time teachers [28%]. It should be noted that ITDs do not hire part-time or three-quarter time teachers.

This reflects the precarious nature of employment in this type of contract.

According to the degree of ITSSMT teachers, they are distributed as follows: 38 teachers have a bachelor's degree [16 F, 22 M], 32 teachers have a master's degree [20 F, 12 M], and 15 teachers have a doctorate [5 F, 10 M].

Of the 24 full-time teachers, 10 are men [42%] and 14 are women [58%]. With regard to the desirable profile, 19 teachers have recognition, 7 of whom are men and 12 are women. However, the teachers with SNII recognition for 2024 are 3 women, 2 with candidate status and 1 with level I status.

The need for a gender perspective in the analysis of the SNII at the TECNM

It is important to recognise teachers through scientific evaluation systems. By 2020, there were 1,202 academics recognised by the National System of Researchers [SNII], of whom 443 are candidates [37%], 663 are level I [55%], 71 are level II [6%], and 19 are level III [2%]. It should be noted that the most common designation is Level I. By 2024, there were 1,773 SNII members affiliated with the TECNM, of whom 498 were candidates [28%], 935 were Level I [53%], 129 were Level II [7%], and 37 were Level III [2%]. Similarly, the contribution that this research aims to make is to identify that the scientific work carried out within the SNII is a social construct under mechanisms of power [Soto, 2017].

The SNII recognition of teachers hired at the TECNM is represented in Table 1, which identifies the evolution of SNII members over the last 9 years.

Box 1

Table 1

Evolution of SNII in the TECNM.

Year	Candidate	SNII Level I	SNII Level II	SNII Level III	Total
2015	185	324	45	10	564
2016	203	355	56	13	627
2017	234	402	56	13	705
2018	275	426	56	12	769
2019	310	493	62	13	878
2020	379	560	65	16	1020
2021	443	669	71	19	1202
2022	450	821	88	30	1389
2023	498	935	129	37	1599
2024	579	1013	140	41	1773

Source: (TECNM, 2024)

Based on these statistical data issued by the [TECNM \(2020, 2024\)](#), there is a need to analyse the representativeness of the SNII from a gender perspective, as there are no statistical data on women and men assigned to the SNII in the TECNM, and a critical feminist perspective is required to distinguish categories such as the sexual division of labour, gender roles, and power relations in patriarchy and capitalism embedded in science and academia.

Research methodology

Gender studies favour qualitative methodology, particularly critical narrative as a possible format consistent with the theoretical foundations of feminism, to show the political and ethical importance of feminist projects ([Beiras, et al 2017](#)). The orientation of this work is based on qualitative research that attempts to understand subjectivity, interactions, and meanings through the interpretation of narratives. These narrative structures serve as guides for interpretation, including thoughts, desires, feelings, and dispositions. The experience is lived, narrated, shared, and reflected upon.

Listening to experiences and narratives allows us to map discourses and experiences [[Nava and Ramos, 2025](#)]. This qualitative methodology allows us to contribute to listening to their demands and projecting them onto the need for public policies. The working hypothesis of the research is: The academic and scientific work carried out by researchers is developed under productivity standards required in science and academia, which rewards high indices while ignoring power relations in public [ITSSMT] and private [domestic] spaces.

This article therefore aims to identify disputes in public spaces as an opportunity for state intervention through public policies. In this regard, [Loaiza \(2025\)](#) refers to the articulation of women's demands at the macrosocial level to 'destructure the social systems that reproduce and internalise gender inequality'. Thus, the strategies carried out by the researchers are specific to their employment status at the ITSSMT, SNII level, academic bodies, teaching activities, outreach, academic management and marital status, caregiving, care for economic dependents, i.e., social reproduction work such as domestic work, caregiving and biological reproduction, which involves specific reconciliation strategies.

The objective of this research is to highlight the academic and scientific work carried out by women members of the SNII in the face of the disputes they experience in private spaces where social reproduction work, domestic work and biological reproduction take place.

At the ITSSMT, of the 85 teachers hired in 2025, only 4 are members of the SNII. As detailed in Table No. 2, 3 of them are women, i.e. 75% of the teaching staff assigned to the ITSSMT.

Box 2

Table 2

Researchers assigned to the ITSSMT in 2025

Pseudonym	Age	Nivel	Marital status	Children	Year of recruitment
Laura	44	I	Married	2 [12 and 14 years]	2008
Diana	57	C	Married	NA	2008
María	54	C	Married	2 [22 Y 24 years]	2019
Juan	44	I	Married	4 daughters	2023

Results

The ITSSMT was contextualised within the educational projects of the regions by identifying the public space where SNII researchers are assigned. Through a critical perspective, it was identified that the ITSSMT is a decentralised technological institute, ranking fifth in order of importance according to its enrolment. The focus of this research is on SNII researchers, of which there will be three by 2025.

This section critically interprets the narratives of teachers affiliated with the ITSSMT. When analysing the meaning of recognition for teachers, they refer to it as not only an economic incentive, but also a source of personal satisfaction. [Aguado y Becerril \(2021\)](#) identify the importance of the SNII as 'the conditional transfer of economic resources from the institutionalised programme.' However, for SNII candidates at the ITSSMT, this financial remuneration is not the only driver of recognition; social and family appreciation, as well as that of students, is also important. This appreciation is complicated by the challenge of balancing activities in the public and private spheres.

More than the financial benefit, I feel socially recognised because my students recognise the academic work I do [Diana, 57 years old, SNII C].

I have just joined the SNII and have no experience in this, but I consider that my main challenge is the time I devote to the ITSSMT to carry out activities. I am aware that remaining in the SNII means working more and more, being productive and, with that productivity, maintaining my position in the SNII [María, 54 years old, married, two children, SNII C].

For me, the SNII appointment is very important financially because I am the breadwinner in my family. My husband has additional income, but it does not match the contribution I make to our family [Laura, 44 years old, two children, SNII level I].

Emotional exhaustion and lack of infrastructure at the ITSSMT

ITSSMT researchers affiliated with the SNII recognise that having an appointment with the SNII brings with it more work and greater stress in maintaining academic work and scientific recognition. [Magaña y Sánchez \(2008\)](#), in a comparative study of emotional exhaustion syndrome between the Technological System, Research Centres and Universities, identified that in the technological system there is emotional exhaustion due to "working conditions such as lack of resources, laboratories and infrastructure. The excessive quantitative and qualitative workload. The multiplicity of roles they have to assume."

The work at ITSSMT in academia, teaching and research is very stressful and has indeed had an impact on my health. My husband tells me that I have given up on work... I am apprehensive about things... something I learned from my father as a child was that if you are going to do something, do it well or don't even bother, make it the best it can be, and that has made me apprehensive, making it difficult for me to relax. If I am in the SNII, more than the financial incentive, it is a source of pride and personal recognition, not for my partner or my children, but for me. It is an achievement and a source of personal satisfaction... Suddenly, I value it and think, "Forget all this, it's too much and I'm just getting started..." [María, 54 years old, married, two children, SNII C].

Here at work within the ITSSMT, I believe that we have teaching, tutoring, outreach and academic management activities that take away time from activities that help us build our CVs and increase productivity to remain in the SNII [María, 54 years old, married, two children, SNII C].

We don't have access to database platforms, we don't have licences. For example, I want to consult journals, but we don't have any agreements, budget or licences to access these scientific databases. We don't even have access to EBSCO [María, 54 years old, married, two children, SNII C].

It should be noted that contracts at the ITSSMT are temporary, and full-time status must be evaluated annually based on productivity. Therefore, there is no stability or certainty in terms of seniority in the employment relationship.

There are SNII researchers in other departments who have job security, but we do not have job security; there is no such thing at this IT [María, 54 years old, married, two children, SNII C].

The type of contract contributes to obtaining recognition, as [Aquino y Álvarez \(2024\)](#) point out, although teachers hired by the hour have greater job insecurity and are therefore less likely to obtain and remain in the SNII. ITSSMT researchers have no certainty regarding their seniority, and the type of full-time appointment represents a type of job insecurity that is rarely addressed.

Domestic work among researchers without gender roles and with older children

[Cortes y Campos \(2024\)](#) refer to the obstacles and limitations that women face when entering the SNII, one of which concerns the sexual division of labour in terms of domestic work. When asked if there is any dispute over domestic work carried out in the private sphere, the researchers report:

At first, it was difficult to balance my family role and adapt to my full-time job as a teacher, but we have been adjusting as we go along, so I have not had any problems.

I have a husband who supports women's development, I have fulfilled myself as a professional, and he is developing in another direction... now I support him, and there is no rivalry as a couple in that sense... [Diana, 57 years old, SNII C].

My children get upset if I bring work home, so I try to do all my ITSSMT work at the university. However, when I have to hand in work, I stay up late to finish the article or chapter that we have as full-time lecturers [Laura, 44 years old, 2 children, SNII level I].

When there is no domestic work or caregiving, there is time to devote to academic and scientific activities. As Gutiérrez and Echeverría [2023] refer to, based on the study by Caldera *et al* (2019), older female researchers have a greater chance of climbing the SNII ladder.

As for balancing family life, we do things as they come up and according to circumstances. When I can't cook or do the housework, I have my mother's support... [Diana, 57 years old, SNII C].

Therefore, when there are no children to care for and there is commitment on the part of the teachers' partners, academic work is not impacted by domestic work.

The study of masculinities in interactions between couples where women are the breadwinners emerges alongside strategies for reconciling public and private spaces. 'Some of the participants negotiate and discuss with their partners, in a rational and explicit manner, how they will manage to keep their jobs, develop their profession and continue to advance in the public sphere and in their working lives' (Castañeda y Contreras, 2021).

Domestic work does not affect me because work at home is not a priority. If I have to sit down to work as a teacher or lecturer, I do not do any work at home, but if I do, it does not matter, we are not demanding ... [Diana, 57 years old, SNII C].

I spend about four hours a day caring for people, two hours on meals, I do not clean, I do not socialise, maybe an hour at most. More than eight hours are devoted to academic and scientific work [María, 54 years old, married, two children, SNII C].

The ITSSMT Level I researcher is younger than the two candidates. She is the leader of the academic body in consolidation, and her strategies for reconciling family and scientific life refer to making academic, research, and management work more efficient.

My mother tells me that 'I'm going to die' if I work in the early hours of the morning, so when we have to submit an article, I have to lie to my mother and say that I didn't stay up late because she worries that I 'don't sleep' because of my research or teaching work [Laura, 44 years old, two children, SNII level I].

Although María [54 years old, married, two children, SNII C] says that she can now devote the necessary time to scientific and academic work, the time spent caring for her children during her postgraduate training was a necessary cost of remaining active in the public sphere of science and academia.

The cost of academic training was sacrificing time together, not being able to go out, but we agreed that my husband would say to me, 'You go first to your master's degree and then I'll go to another training course,' and he was attentive, asking me what I needed for my professional development [Diana, 57 years old, SNII C].

Joint responsibility of couples

The strategies used and developed by the participants to achieve this harmonisation are diverse. On the one hand, they consist of organising and coordinating with their partner the study and training times of each member of the relationship; for example, one member of the couple does a postgraduate degree and then the other (Castañeda y Contreras, 2021)

The way my husband contributes is that, because he has a career similar to mine, he reads my articles and gives me feedback... [Diana, 57 years old, SNII C].

Castañeda y Contreras (2021) point out that ‘it is important to analyse not only women, their work-life balance strategies and their life plans, but also to include in the discussion the attack on masculinity that many men experience’. In the case of the ITSSMT researchers, they have defended and built their careers through the mediation of strategies with their husbands.

I did the caregiving work from Monday to Friday, and when my husband helped me with that, it was quite a challenge for him because one summer when I had to work, he had to stay with the children. He had never been 100% in charge before, but he supported me a lot when I returned to teaching. I would go in the morning to drop my son off at nursery, and my husband took care of our daughter. He had to learn how to comb the girl's hair and give her breakfast, and that was great for me and my daughter.

That's when I felt truly supported. We only had one car, and I took it. I've seen couples where the man uses the car, but I always took the car. My husband used public transport. There was a semester when I started work at 8 a.m. and my husband had to take care of combing our daughter's hair, take the minibus with her backpack and his, drop her off at nursery, and pick her up when I finished work [María, 54, married, two children, SNII C].

During the years I was in graduate school, he was in the national union and was away a lot. He went to national meetings and sometimes came home for a week and then left for work for a week. We got used to him not being there. He didn't mind so much because he was involved in other things, travelling all over the country. It was my children who minded.

They told me themselves when I finished my doctorate, “We don't want you to study anymore.” I admit that I was at home, supposedly looking after them, but I was also involved in my doctorate [María, 54 years old, married, two children, SNII C].

My husband doesn't like to cook, so I have to organise and prepare what we are going to eat or buy. My husband has had anxiety attacks when doing housework [Laura, 44 years old, two children, SNII level I].

Although 54-year-old teacher María was appointed as a candidate a year ago, in 2024, it was during the period when she was caring for her children that she consolidated her postgraduate studies with the ‘support’ of her husband. In her narrative, she refers to how difficult it was for ‘him’ but that, for them, mother and daughter, it was a “great” experience, as now it was ‘his’ turn to even comb their daughter's hair and take her to nursery.

When my children were small, I devoted myself solely to the home and to caring for them. It was a challenge. The children were younger and required a lot of my care. I never left them with anyone. The person who really supported me was my husband. I would go to my doctoral classes in the evening from 7 to 10 p.m. By that time, he would arrive and take care of the children, and I would go to the university [María, 54 years old, married, two children, SNII C].

Motherhood and science

Motherhood and science is an epistemic crossroads under debate. Palomar (2009) points out that ‘the social construction of motherhood is a revelation of the social gender order.’ However, this research is based on the hypothesis that the social reproduction work carried out by women is an important factor in the positioning of the SNII.

I was not a mother, but I think if I had been, it would have had an impact on my productivity. My professional growth is focused on my family, on my husband, who is proud of me. We talk about ourselves as a family and about the achievements I have made, such as my appointment to the SNII [Diana, 57 years old, SNII C].

The exercise of motherhood goes beyond the subjective experience described by Palomar (2009) and represents a form of social reproduction that affects the way academic and scientific work is carried out. That is why the construction of the experience of motherhood in the academic world would reveal new aspects of both that experience and the nature of higher education institutions Palomar (2009).

The decision to become a mother in the career of female academics

When I first got married, I was working in industry by mutual agreement. I did not get pregnant immediately; my thinking was not to have children at that time. I considered it important to spend some time alone without children. It was not in my plans to have children; I had considered not having a family when I was newly married. I had the choice and my husband agreed [María, 54 years old, married, two children, SNII C].

Once I decided to have children, the decision was that one of us had to take care of them. I simply felt that I would never leave the upbringing of my children to someone else, whether it was my brother or my mother. It was my own decision to leave my career and devote myself 100 per cent to my children [María, 54 years old, married, two children, SNII C].

When I became pregnant with my daughter, I began studying for my master's degree, and when I became pregnant with my second child, I began studying for my doctorate [María, 54 years old, SNII C].

Motherhood and teaching

I decided to work in teaching because it allowed me to work a few hours. My strategy was that while I was at work, my children were in kindergarten and nursery school. I would go to my classes for two or three hours, drop them off, and when I left work, I would devote myself to my children [María, 54 years old, married, two children, SNII C].

My family has helped me care for my children, as I have had support from my husband, my father, and my mother to look after my children, so motherhood has been bearable because I have had their support [Laura, 44 years old, two children, SNII level I].

Support when caring for young children

I never used nurseries. When they were at school, I used that time to work outside the home [María, 54 years old, married, two children, SNII C]. As for the care of my children, I did not have any support networks.

I took care of them myself, and the only person I needed support from was one of my sisters, who helped me sporadically [María, 54 years old, married, two children, SNII C].

The age of the researchers as a limitation of the SNII

Until 2020, there was an age restriction for entering the SNII, as Article 4 RSNI [2020] stated as a requirement: 'd. Be under 40 years of age at the close of the Call for Applications, with exceptions to be decided by the Adjudication Committees.'

In this regard, researcher Diana [57 years old, SNII C] states that she did not plan to join even though she met the productivity requirements, as she has been with the ITSSM for 17 years and has been a full-time professor for 10 years.

I have been working full-time for 10 years and have 17 years of service at ITSSMT. A year ago, I was appointed to the SNII. To be honest, I did not plan to join the SNII because I was already over the age limit required by the SNII. I thought that door was closed for me... That didn't hinder my professional growth because I had an impact on the students, but when this opportunity opened up, I was very happy... It's one of the greatest satisfactions I've had professionally... [Diana, 57 years old, SNII C]. The researchers who are affiliated with the SNII as candidates have an average age of 54 years and one year of seniority in the evaluation system.

I worked at this same institution more than 15 years ago. I returned in 2019 to work at the ITSSMT. I was granted candidate status a year ago [María, 54 years old, SNII C].

The level I researcher [Laura, 44 years old, Level I] has 18 years of seniority at ITSSMT and her first SNII appointment was in 2020 as a candidate, with a one-year extension in 2024 due to illness and a level I appointment in 2025.

Cost of productivity in interpersonal relationships within the domestic sphere

Unfortunately, there is a cost. For example, I spent four years doing my doctorate, at home but not really there, as my children said.

Those years were so absorbing with my doctoral studies that I neglected my partner and my children because they required a lot of time [Maria, 54 years old, married, two children, SNII C].

When I received my appointment to the SNII five years ago, it was a difficult time for me because I got divorced, although I remarried my husband. There were times when I thought I had neglected my family, and it crossed my mind to resign full-time to devote myself to my family [Laura, 44 years old, two children, SNII level I]. I had never dreamed of being in the SNII. I didn't seek this out; it just happened, and here we are. It has been a sacrifice to put my family, my children, and my partner aside. Right now, we can say that my children are grown up and don't need me as much anymore.

They are independent, but I feel that when they needed me most, I was a little absent. If you want to get something, you have to sacrifice something. You can't have everything without making sacrifices [Maria, 54 years old, married, two children, SNII C].

I requested a one-year extension due to illness. I have had health complications, and my family tells me it is due to stress. It worries me because I am the breadwinner for my family, so I constantly get check-ups to put my mind at ease [Laura, 44 years old, two children, SNII level I].

Motivations for personal satisfaction in pursuing a postgraduate degree

I found my studies particularly difficult because I didn't have the foundation, as I did my primary education at an adult school in six months, not like everyone else, and then secondary school is not the same, because I did it at the INEA in three years.

All of that had an impact on me and made things difficult. It has been complicated, it has taken a lot of dedication in a way, I have sacrificed my family, but I think it has been worth it. It is a personal satisfaction, not so that people will call me "doctor", but simply for personal satisfaction. It is doing a postgraduate degree for satisfaction, not to achieve better living conditions [María, 54 years old, married, two children, SNII C].

Conclusions

The SNII was created in 1984 and represents recognition of female and male researchers through categories recognised for scientific productivity. The representation of women has increased since the creation of the SNII, reaching 40% by 2025 according to data from the SNII census issued by SECIHTI.

Particularly in the higher education subsystem of decentralised technological institutions, such as the ITSSMT, it can be seen that by 2025 there are three women affiliated with the ITD with a level I distinction and two with candidate level distinctions.

The Level I researcher is married, aged 44, and the two Level Candidate researchers are aged 54 and 57. In their narratives, the interviewees point out that academic work, tutoring, management, and outreach represent a challenge due to the lack of infrastructure, such as access to scientific journal databases, or restricted funding from the institution for research. The type of contract exacerbates the situation, as they have to be evaluated every year to continue working at the institution.

The scientific work carried out is characterised by stress, burnout and emotional exhaustion that they have had to face at some point in their performance in the face of the various requirements of the different activities when hired in the full-time category.

With regard to the reconciliation of private and scientific life, they point out that researchers who have been responsible for children, either during postgraduate training or during their SNII appointment, have an increased social reproduction workload that reduces their scientific productivity.

The exercise of non-hegemonic masculinities, such as shared responsibility for childcare or domestic work, is a necessary requirement for reducing the hours of social reproduction work. In the case of the Level I researcher, being the leader of the only academic body in consolidation at the ITSSMT has meant that she has had to implement work efficiency strategies at the technological institute, as her children demand her time at home. This has also caused stress with her partner, who is not jointly responsible for domestic work.

It is concluded that the researchers affiliated with the SNII at the ITSSMT have implemented strategies that lead to emotional exhaustion and health problems due to the workload required by the institution. However, recognition by the evaluation system gives them personal satisfaction on the one hand and, on the other, financial incentives for the scientific work they have carried out.

The age at which the two candidate researchers obtained their appointments shows that the adaptation of public policies with a gender perspective allowed them access to the system, as they had the required productivity and experience in teaching and science.

In the case of the Level I researcher, collaborative work by the ITSSMT consolidation body allows her to establish networking strategies with the members of the body, which contribute to joint productivity.

Although belonging to an ITD represents a challenge, the three researchers demonstrate the hard work carried out at the ITSSMT. It is worth recognising that the SNII researchers at the technological institute are women and that the social reproduction work carried out in their domestic spheres requires contributions with co-responsibility on the part of their partners and that the time devoted to childcare, domestic work and biological reproduction is a factor present in the trajectories of female scientists.

Conflict of interest

The authors declare that they have 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.

Contribution of the authors

The contributions of the researchers were as follows:

Soto-Rivas, Soledad: Conducts the research and writes the article. Applies a qualitative methodology with a gender perspective in order to vindicate the reproductive work carried out by the subjects of the study.

Hernández-Hernández, María Elena: Contributed to the systematisation of the background information for the state of the art, verifying the references. Contributed to the writing of the article.

Irigoyen-Arroyo, Luis Ernesto: Conducted interviews with the TecNM researchers, contributing to the writing of the interviews.

Availability of data and materials

Data and materials are available to readers. Personal interviews were conducted and information was collected.

Funding

This project did not receive funding.

Acknowledgements

We would like to thank ITSSMT, TecNM, SECIHTI, and CIISDER for providing the scientific human capital.

Abbreviations

CIISDER	Centre for Interdisciplinary Research on Regional Development
ESDEPED	Incentives for Teaching Staff Performance
ITD	Decentralised Technological Institute
ITF	Federal Technological Institute
ITSSMT	Higher Technological Institute of San Martín Texmelucan
PRODEP	Programme for Professional Development of Teachers
TecNM	National Technological Institute of Mexico
SDE	Emotional Exhaustion Syndrome
SNII	National System of Researchers

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Technological acceptance of the use of AI tools by Mechatronic Engineering students at the UTD

Aceptación Tecnológica del uso de herramientas de IA en los alumnos de Ingeniería Mecatrónica de la UTD

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Classification:

Area: Humanities and Behavioural Sciences

Field: Pedagogy

Discipline: Educational theory and methods

Subdiscipline: Other

<https://doi.org/10.35429/JUM.2025.9.20.3.1.8>

History of the article:

Received: June 07, 2025

Accepted: November, 2025

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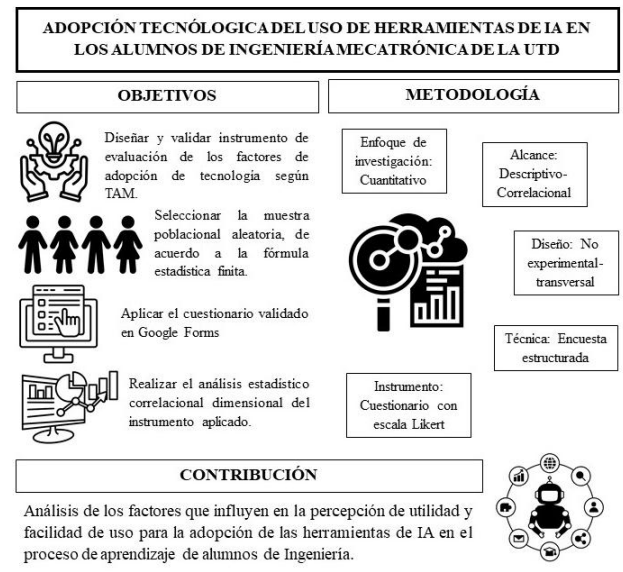
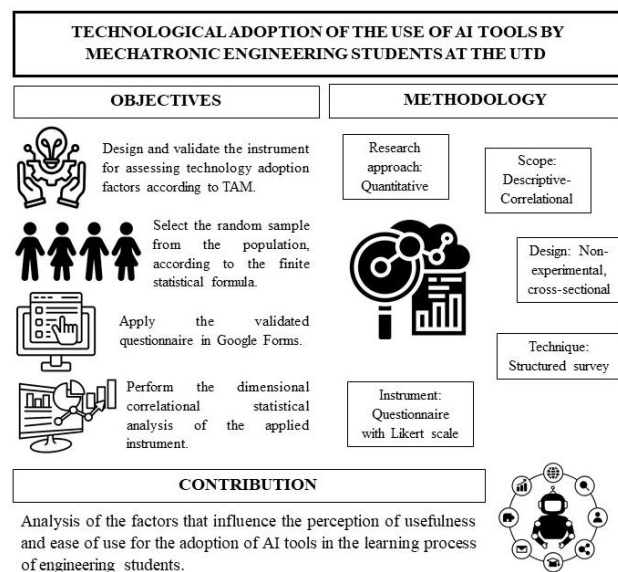


Abstract

This research aimed to evaluate the factors that influence the adoption of AI tools by students at the Technological University of Durango, considering the dimensions of perceived usefulness, perceived ease of use, attitude toward technology, and intention to use, based on the Technology Acceptance Model [TAM]. A twenty-item questionnaire was designed and administered, validated with an Aiken's V coefficient of 0.97 and Cronbach's Alpha of 0.94. This instrument was administered to 149 students, and its statistical analysis showed that perceived usefulness is an important predictor of intention to use, with a correlation r of 0.647, given that students perceive the use of AI in their academic process as useful because it facilitates access to information and makes academic tasks more efficient.

Resumen

Esta investigación se orientó a evaluar los factores que influyen en la adopción de herramientas de IA por parte de los alumnos de la Universidad Tecnológica de Durango, considerando las dimensiones de percepción de utilidad, percepción de facilidad de uso, actitud hacia la tecnología e intención de uso, basadas en el Modelo de Aceptación de la Tecnología [TAM]. Se diseñó y aplicó un cuestionario de veinte ítems validado mediante coeficiente V de Aiken de 0.97 y Alfa de Cronbach de 0.94. Este instrumento se aplicó a 149 alumnos y su análisis estadístico mostró que la percepción de utilidad es un predictor importante en la intención de uso, mostrando una correlación r de 0.647, dado que los alumnos perciben útil el uso de la IA en su proceso académico ya que facilita el acceso a la información y eficientiza la realización de tareas académicas.



Artificial Intelligence, Perception, Technology Acceptance Model [TAM]

Inteligencia Artificial, Percepción, Modelo de Aceptación Tecnológica [TAM]

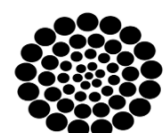
Area: Development of strategic leading-edge technologies and open innovation for social transformation

Citation: García-Arámbula, Cintia Germania, Beltrán-Zhizhko, Gali Aleksandra, Marrufo, Luis Fernando and Herrera-González, Raúl Iván. [2025]. Technological acceptance of the use of AI tools by Mechatronic Engineering students at the UTD. Journal University Management. 9[20] 1-8: e3920108



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Introduction

The incorporation of digital technologies into educational processes has brought about radical changes in the way students learn [UNESCO, 2019b]. Artificial Intelligence [AI] is based on the analysis of the human ability to reason according to their perceptions of facts and relationships between them, in order to obtain answers and develop knowledge. Currently, this technology has developed multiple applications to facilitate human tasks, among which the main functions include decision-making, pattern recognition, prediction, and autonomous learning [Russell & Norvig, 2016].

In 2005, Siemens emphasized that learning in the digital age requires a new theoretical understanding that includes connectivity and automation, given that AI represents an active component in students' cognitive processes. Zhang and Aslan [2021] mentioned that AI in education involves the study of areas such as computer science, learning sciences, psychology, neuroscience, linguistics, and other disciplines necessary to develop personal, adaptive, and effective learning environments to optimize traditional education. In this sense, AI has established itself as a strategic tool that promotes revolutionizing education through the personalization of learning, the analysis of educational data, and the automation of administrative tasks [Kamalov *et al.*, 2023].

The role of AI in learning lies in the use of intelligent simulators to facilitate tasks or processes of design and research in the field of education, by solving machine learning algorithms based on neural network models, using a representation and calculation method based on deep learning whose applications allow computers to learn to perform a myriad of tasks that promote learning, decision-making, problem-solving, language comprehension, and visual perception [Fernández De Silva, 2023].

The use of AI in education faces various challenges, including the lack of coherent public policies, limited technological infrastructure in educational centers, and a lack of teacher training. Combined with ethical and legal tensions surrounding the handling of personal data, this makes it necessary to establish regulatory frameworks to ensure its responsible and equitable use [UNESCO, 2019a].

Despite the incorporation of these technologies into the educational context, students' perceptions of their use are a determining factor in their acceptance, adoption, and effective use in their academic tasks. In this sense, perception is a cognitive process of consciousness [Allport, 1974], where students develop attitudes, beliefs, and feelings regarding the usefulness, ease of use, and ethical aspects of AI in their educational process. Understanding technology adoption processes allows us to assess the psychological, social, and technological aspects of the educational context, as well as the preferences and behavior of students in the digital age.

Several studies indicate that the main problem lies in understanding how students perceive AI, as this can directly influence their willingness to use these tools and take advantage of their benefits in their learning, given that a negative perception can limit their effective integration. Among the main studies, one conducted by Latifa Alzahrani in 2023 stands out, determining that facilitating conditions influence students' intention to use AI [Alzahrani, 2023].

Therefore, it is necessary to understand how students perceive the use of this technology in order to design pedagogical strategies that foster a positive attitude toward the responsible and ethical use of AI, as well as facilitate its acceptance and optimize its benefits in training processes.

This research was based on the Technology Acceptance Model [TAM] proposed by Fred Davis in 1986 to determine how factors of usefulness and ease of use influence students' perceptions of AI use and define its adoption in the educational context. This model is based on Reasoned Action Theory and uses measurement scales that predict user acceptance through psychometric properties, replacing attitudinal beliefs with constructs of perceived usefulness and perceived ease of use [Buabeng-Andoh, 2018].

This research took a quantitative approach, with a descriptive and correlational scope, whose objective was to evaluate students' perceptions of the use of AI in their learning process. The study population consisted of 236 students from the Mechatronics Engineering program at the Technological University of Durango in Durango, Mexico.

The research identified patterns of behavior and attitudes toward the use of AI by students. The results of the study provide scientific evidence that suggests the recurrent and indiscriminate use of this tool, influenced by sociocultural factors and technological trends, revealing the need to integrate AI content into the university curriculum through training and awareness programs that address technical and ethical aspects.

This analysis will contribute to strengthening the framework for the implementation of emerging technologies at the Technological University of Durango, promoting a more inclusive educational environment that is receptive to the challenges of the digital age.

Methodology

In this research, taking into account the study object, a quantitative approach was selected, with a descriptive and correlational scope, to find the relationship between the factors involved in the technological acceptance of AI and the learning process. The phenomenon is observed in its natural context without manipulation of variables, making this research non-experimental and cross-sectional research, given that the data was collected at a single point in time. The technique used is a survey, applying a structured questionnaire for data collection, facilitating quantitative analysis.

The stages of methodological development are shown in the figure 1 below.

Box 1

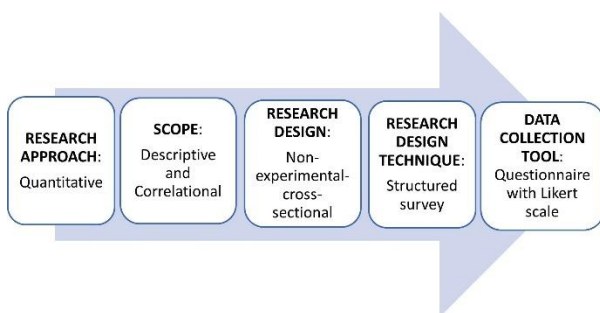


Figure 1

Research methodology approach

Source: Own elaboration

The first step in the process was to conceptualize and operationalize the variables, considering different criteria as presented in the following tables 1 to 4.

Box 2

Table 1

Variable: Perceived Utility [PU]

Dimension	Indicator	Item	Likert Scale
Efficiency	Improvement in academic performance	Using AI tools improves my academic performance	1=Strongly disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly agree
Relevance	Relevance to learning and academic activities	I believe AI is important for achieving my learning goals.	
Productivity	Increase in academic productivity	AI tools help me complete my tasks more efficiently.	

Source: Own elaboration

Box 3

Table 2

Variable: Perception of Ease of Use [PEU]

Dimension	Indicator	Item	Likert Scale
Simplicity	Ease of learning and use.	It is easy to learn how to use AI tools.	1=Strongly disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly agree
Accessibility	Availability and ease of access to AI tools	AI tools are readily available for use in academic activities.	
Intuition	Clarity of intuition in tool interfaces	The interface of AI tools is easy to understand and use.	

Source: Own elaboration

Box 4

Table 3

Variable: Attitude toward Technology Acceptance [ATA]

Dimension	Indicator	Item	Likert Scale
Simplicity	General willingness to use AI in education.	I feel positive about using AI in my learning.	1=Strongly disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly agree
Accessibility	Level of curiosity and motivation to explore AI tools.	I am interested in learning more about AI tools and their applications.	
Intuition	Confidence in the usefulness of AI tools.	I trust that AI tools are useful and reliable for learning.	

Source: Own Elaboration

Box 5**Table 4**

Variable: Intention to Use [IU]

Dimension	Indicator	Item	Likert Scale
Disposition	Willingness to adopt AI tools in academic activities.	I am willing to use AI tools for my academic tasks.	1=Strongly disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly agree
Persistence	Intention to continue using AI in the future.	I plan to continue using tools in my studies.	
Application	Degree of AI integration in specific activities.	I will use AI tools to solve complex problems in my tasks.	

Source: Own elaboration

In accordance with the operationalization of variables based on TAM, a structured survey was designed, with 20-item considering a Likert scale. The questionnaire was submitted to expert review to validate its content, according to the criteria established in the following table 5.

Box 6**Table 5**

Criteria to validate the survey's content by experts' review

Indicators	Criteria
Clarity	Appropriate language.
Objectivity	Expressed in observable behaviors.
Organization	Logical organization.
Sufficiency	Comprises aspects that are investigated.
Intentionality	Suitable for assessing the research object.
Coherence	Manifested in the questions asked.
Methodology	It is adequate.

Source: Own elaboration

The shown criteria were applied to each of the items of the survey. Then the experts could judge each item in a scale from 0 to 100 points, considering Deficient [0-40], Regular [41-60], Good [61-90] and Excellent [91-100].

Next, to measure the relevance of each item with respect to its construct, Aiken's V coefficient [V] was considered based on five expert judges in Educational Technology. Equation 1 shows how to calculate the mentioned coefficient.

$$V = \frac{\bar{x} - l}{k} \quad [1]$$

Where:

V: Aiken's V coefficient

 \bar{x} : average rating from judges

k: grade range [Max-Min]

l: lowest possible rating

In order to measure the instrument's reliability, the survey was applied to 42 students and the correlation of each item was determined using Cronbach's alpha coefficient, to assess the internal consistency of the instrument according to equation 2.

$$\alpha = \frac{K}{K-1} \left[1 - \frac{\sum_{i=1}^K S_i}{St} \right] \quad [2]$$

Where:

K: number of items

 S_i : variance of each item S_t : variance of all the items

The next step in the methodology was to apply the instrument to a sample of the population. The sample size was calculated based on the enrolment in the Mechatronics Engineering program for the May-August 2025 quarter, corresponding to 236 students. The finite sample was calculated using the following statistical formula [equation 3].

$$n = \frac{N * Z_{\alpha}^2 * p * q}{e^2 * (N-1) + Z_{\alpha}^2 * p * q} \quad [3]$$

Where:

n: size of the finite sample

N: population size

Z: statistical parameter that depends on the Confidence Level [CL]. Value of 1.96

e: maximum acceptable estimation error. Value 5%.

p: probability of occurrence of the studied event [success]. Value 50%.

q = [1 - p]: Probability of non-occurrence of the studied event. Value 50%.

The structured questionnaire in Google Forms was administered to 146 Mechatronics Engineering students at the Technological University of Durango to measure the dimensions of perception of AI use. For the correlational statistical analysis, SPSS version 27 software was used to identify the effect of the independent variables [perception of ease of use, attitude toward technology acceptance and intention to use] on the dependent variable [perceived usefulness] measured with Spearman's coefficient.

Results

Starting with the design and instrument’s validation stage, the results from the statistical analysis of the experts’ judgement are presented. Five expert judges in Educational Technology analyzed the items taking into account the criteria mentioned in the Methodology section, and from that a mean value of 3.99 was obtained, with a standard deviation of 0.14.

Applying equation 1, a value of 0.97 for Aiken’s V coefficient was found. This is considered a very high score for Aiken’s V coefficient, which, according to Charter [2003], means that the instrument is considered to have adequate content validity.

To determine reliability of the instrument, the responses from 30 questionnaires administered during the pilot phase were analyzed using the same SPSS software, to get the Cronbach’s alpha value, which was of 0.951.

According to the criteria established by George and Mallery [2003], Cronbach’s alpha values above 0.90 indicate an excellent level of reliability, which means that the items have high internal consistency and measure the proposed construct in a consistent manner.

Likewise, the correlations between the elements were analyzed to determine the degree to which the items measure the same variable [table 6].

Box 7

Table 6

Statistics for the correlations between the elements

	Mean	Mín	Max	Range	Max / Mín	Variance
Element’s means	3,715	3,233	4,033	,800	1,247	,048
Covariances between elements	0,475	,094	1,057	,963	11,220	,035
Correlations between elements	0,507	,086	,862	,776	10,043	,037

Source: Own Elaboration

The table above shows the descriptive statistics associated with the internal consistency analysis of the instrument. Regarding the correlations between items, the average was 0.507, with a minimum of 0.086 and a maximum of 0.862, with a range of 0.776. The maximum relationship was 10.043 and the variance was 0.037.

These values suggest that most items have moderate to high correlations, indicating that they measure aspects related to the proposed construct.

After applying the survey, a statistical analysis of the instrument was performed, to assess perceptions of AI use. From the 146 sample of students, it was determined that 125 were male [85.6%] and 21 female [14.4%], indicating a predominance of male participants in the study.

The gender frequency difference does not influence the use of AI tools in the learning process; it is simply due to the normal behavior in careers with this profile, given historical, sociocultural, and educational factors.

Next, the analysis of each dimension is shown. Starting with Perceived Usefulness [PU], the analysis revealed a central value [median] of 4 corresponding to the “Agree” level, where students agree that the use of AI improves their academic performance as it allows them to increase their productivity, as shown in the following table 7.

Box 8

Table 7

Frequency analysis of the dimension Perceived usefulness [PU]

PU levels according to Likert scale	Frequencies	% from total	Cumulative %
1	2	1.4%	1.4%
2	2	1.4%	2.7%
3	12	8.2%	11.0%
4	81	55.5%	66.4%
5	49	33.6%	100.0%

Source: Own Elaboration

As can be seen in the previous table, most participants rate the usefulness of the tool positively, and this influences its acceptance and use in accordance with the Technology Acceptance Model [TAM].

Continuing the analysis of Perception of Ease of Use [PEU], in this dimension, items were evaluated using criteria such as the ease of use of AI interfaces. The results present a median score of 4, where students agreed that ease of use promotes the constant use of AI in academic activities [table 8].

Box 9**Table 8**

Frequency analysis of the dimension Perception of Ease of Use [PEU]

PEU levels according to Likert scale	Frequencies	% from total	Cumulative %
1	2	1.4%	1.4%
2	2	1.4%	2.7%
3	15	10.3%	13.0%
4	57	39.0%	52.1%
5	70	47.9%	100%

Source: Own Elaboration

The next analyzed dimension was Attitude toward Technology Acceptance [ATA]. Here, 80.2% of the surveyed students reflect a generally positive attitude toward the use of technology, corresponding to the levels 4 and 5 on the Likert scale. This shows a favorable disposition toward the adoption and application of AI [table 9].

Box 10**Table 9**

Frequency analysis of the dimension Attitude toward Technology Acceptance [ATA]

ATA levels according to Likert scale	Frequencies	% from total	Cumulative %
1	2	1.4%	1.4%
2	3	2.1%	3.4%
3	24	16.4%	19.9%
4	69	47.3%	67.7%
5	48	32.9%	100.0%

Source: Own Elaboration

Finally, for the dimension of Intention to Use [IU] a value of 4 was obtained for the median on a Likert scale, representing that at least 50% of the participants expressed a high level of intention to use the technology, with a general tendency toward a high predisposition to use it in their learning process. The frequencies of Intention to Use [IU] are shown in table 10 below.

Box 11**Table 10**

Frequency analysis of the dimension Intention to Use [IU]

IU levels according to Likert scale	Frequencies	% from total	Cumulative %
1	3	2.1%	1.4%
2	2	1.4%	3.4%
3	21	14.4%	17.8%
4	70	47.9%	65.8%
5	50	34.9%	100.0%

Source: Own elaboration

The table above shows a negative asymmetry in the frequency distribution and a concentration toward the high values on the scale, suggesting that most participants perceive the technology positively and also show a strong intention to adapt and use it.

As a last step, a dimensional correlation analysis was applied. Spearman's coefficient was applied to find correlations between the dimensions: Perception of Usefulness, Perception of Ease of Use, Attitude toward Technology Acceptance, and Intention to Use.

The results showed positive and significant correlations [$p < 0.001$], ranging from moderate to high in magnitude, indicating that higher levels in one dimension tend to be associated with higher levels in the other dimensions [table 11].

Box 12**Table 11**

Spearman's correlations matrix

Dimensions	PU	PEU	ATA	IU
PU	-			
PEU	0.381 ***	-		
ATA	0.576 ***	0.390 ***	-	
IU	0.647 ***	0.436 ***	0.664 ***	-

Note: H_a is positive correlation.

Note: * $p < .05$, ** $p < .01$, *** $p < .001$, one tail.

Source: Own Elaboration

Table 11 shows a moderate positive correlation in terms of perceived ease of use, meaning that the easier the technology is to use, the more useful students perceive it to be. Meanwhile, perceived usefulness has a considerable influence on students' attitudes toward technology, showing a correlation value r of 0.576.

Perceived usefulness is an important predictor of intention to use, showing a correlation r of 0.647, since if students find the technology useful, they will be more inclined to use it. In general, all the dimensions evaluated are significant in Perceived Usefulness according to the Technology Acceptance Model [TAM].

Conclusions

This research highlights students' genuine interest in integrating AI into their academic work and research as part of their learning process, as high scores were obtained on the Likert scale in terms of their intention to use this tool.

The results also showed positive and significant correlations between perceived usefulness, ease of use, attitude, and intention to use, thus reinforcing the hypothesis that a positive perception generates greater willingness and openness to adopt AI tools.

However, concerns arise regarding the handling and privacy of personal data, making it imperative for institutions to establish regulatory policies on the use of AI in academic contexts, since training in ethical values and the social implications of AI must be a priority in order to prevent malicious use of information.

Currently, the implementation of AI in educational institutions faces significant structural obstacles, with insufficient technological infrastructure, a lack of coordinated public policies, and a lack of teacher training in digital pedagogy constituting the main barriers. In addition, the marked difference in technology adoption between urban and rural public institutions creates a digital technology access gap. On the other hand, it is necessary to incorporate the use of AI more emphatically into academic curricula to promote formal and systematic learning, considering theoretical, practical, and ethical components.

Some of the authors' recommendations for integrating AI into educational environments are:

- Create an institutional critical digital literacy program that considers ethical, technical, and social components.
- Promote a program of continuous training for academic staff in digital technology and pedagogical methodologies that integrate multiple intelligences and active learning.

Declarations

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

Garcia-Arambula, Cintia Germania. Contributed to the research idea, the method and the writing of the article.

Beltran-Zhizhko, Gali Aleksandra. Contributed to the research technique, the translation and revision of the article.

Marrufo, Luis Fernando. Contributed with applying the technique and the statistical analysis.

Herrera-Gonzalez, Raul Ivan. Contributed with the statistical analysis and revision of the article.

Availability of data and materials

The data analyzed in this article was collected directly by the authors.

Funding

The research did not receive any funding.

Acknowledgements

We acknowledge Technological University of Durango for its contribution to this work.

Abbreviations

AI – Artificial Intelligence
 UTD – Universidad Tecnológica de Durango
 TAM – Technology Acceptance Model
 ATA – Attitude toward Technology Acceptance
 IU – Intention to Use
 PU – Perceived Utility
 PEU – Perception of Ease of Use

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Antecedents

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Basics

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Durango 2024 learning assessment results. Statistical analysis of the mathematics area

Resultados de evaluación de los aprendizajes Durango 2024. Análisis estadístico del área de matemáticas

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Classification:

Area: Humanities and Behavioral Sciences
Field: Pedagogy
Discipline: Educational Theory and Methods
Subdiscipline: Evaluation of Students

 <https://doi.org/10.35429/JUM.2025.9.20.4.1.10>

History of the article:

Received: October 07, 2025

Accepted: November, 2025

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



Abstract

This document shares the results found in the descriptive analysis of the exam "Evaluation of learning Durango 2024", in the introduction we find the reasons for this evaluation and its purpose, it also presents a theoretical support for evaluation, standardized tests and the legal foundations that gave rise to this evaluation; from a quantitative approach, the analysis of the data is proposed using descriptive statistics, since the study is not a quasi-experimental or experimental research, the study aims to identify the level of achievement of students from third to sixth grades of primary education in knowledge in the area of mathematics; the discussion of results and conclusions are based precisely on the results obtained, validating the assumption that "students from third to sixth grade have conceptual and procedural deficiencies in learning mathematical content.

Resumen






El presente documento comparte los resultados encontrados en el análisis descriptivo del examen "evaluación de los aprendizajes Durango 2024", en la introducción encontramos los porque de esta evaluación y el propósito de la misma, también presenta un soporte teórico de evaluación, exámenes estandarizados y los fundamentos legales que dieron origen a la misma; desde un enfoque cuantitativo, se plantea el análisis de los datos empleando la estadística descriptiva, pues el estudio no es una investigación cuasi experimental o experimental, el estudio tiene como objetivo identificar el nivel de logro de los alumnos de tercero a sexto grados de educación primaria en los conocimientos en el área de matemáticas; la discusión de resultados y las conclusiones se basan precisamente en los resultados obtenidos, validando el supuesto que "los alumnos de tercero a sexto grado tienen deficiencias conceptuales y procedimentales en el aprendizaje de contenidos matemáticos

Durango 2024 Learning Assessment Results. Statistical Analysis of the Mathematics Area

Objectives	Methodology	Contribution
Report the results obtained in the standardized test 'Durango 2024 Learning Assessment. Primary'	Quantitative Approach, Non-experimental,	Identify areas for improvement in learning
	 	 
	Exploratory, Transversal	It contributes to reflection on the necessary learning in mathematics.

Educational assessment, Descriptive statistics, Standardized tests

Resultados de Evaluación de los Aprendizajes Durango 2024. Análisis Estadístico del Área de Matemáticas

Objetivos	Metodología	Contribución
Dar a conocer resultados obtenidos en el examen estandarizado "Evaluación de los aprendizajes. Durango 2024"	Enfoque Cuantitativo No experimental	Identificar áreas susceptibles de mejora en los aprendizajes
	 	 
	Exploratorio, Transversal	Contribuye a la reflexión sobre los aprendizajes necesarios en el área de matemáticas

Evaluación educativa, Estadística descriptiva, Pruebas estandarizadas

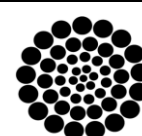
Area: Promotion of frontier research and basic science in all fields of knowledge

Citation: Díaz-Ledezma, José de la Cruz, Lino-Gamiño, Juan Alfredo and Torres-Gutiérrez, Arturo. [2025]. Durango 2024 learning assessment results. Statistical analysis of the mathematics area. Journal University Management. 9[20] 1-10: e4920110



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Introduction

The purpose of this product is to report the results obtained in the standardized test 'Durango 2024 Learning Assessment. Primary', administered in April 2024. The aim of this test was to assess the learning achieved by pupils in grades three to six of primary education. This document presents the results from four schools in school zone No. 128, which are federally funded and represent a significant sample of the total number of pupils in these grades, approximately 65% of the total school population.

The exam [and its validation] and the implementation strategy were designed entirely by the Durango State Department of Education [SEED] through the Undersecretary of Educational Services. It was also determined that the exams would be administered by the same teachers from each school, with the presence of an internal observer from the school zone [specifically a teacher or administrator from another school in the same area] who was responsible for recording the start and end of the exam, as well as any incidents that occurred during the process. The exam was administered over two school days and also involved the participation of parents who, like the internal observer, were also required to report on the exam using a Google Forms questionnaire.

The exam for third to fifth grades consisted of 40 questions, and the sixth-grade exam consisted of 38 questions. The analysis presented here serves to show those questions in which students in each grade show the greatest deficiencies in learning achievement.

This analysis aims to inform the principals of the sample schools of the results so that, at a given moment, they can make decisions that will lead to improved learning. When they meet with the teaching staff, they will identify the questions that show inadequate results so that, together, they can design a path that will contribute to better results in the teaching process and, consequently, in learning. promoting, through reflection, analysis, and criticism of their own work and its results, the use of the learning projects proposed in the teaching methodology in the curriculum, as well as the proposal of alternatives that support the achievement of learning in relation to the content and the Learning Development Processes [LDP].

The document presented here intentionally starts from the assumption that students in grades three to six have conceptual and procedural deficiencies in learning the content and LDPs. Within this framework, the aim is to identify students' achievement levels through collegial analysis of the results in order to take the appropriate actions to improve results.

This document presents the thematic development organized into sections that allow us to delve into the process of analyzing the results. Among these sections, we find one related to the theoretical references that support the concept of assessment, the application of standardized tests [their meaning, purposes, and scope], and the legal framework on which this assessment for state students is based. The following section develops the methodology used to carry out the analysis [of a purely descriptive nature]. The next section presents the results supported by tables and graphs obtained from the analysis. Subsequently, the conclusions of this analysis are presented. Finally, there is a section on the references that were taken into account in the preparation of each section of this document.

Assessment. An approach to its meaning

Assessment has been a constant in education systems, both to evaluate learning outcomes and to evaluate the actions carried out in the classroom and, at a given moment, to evaluate the path taken by the education system in the training and education of students at different levels.

There is no doubt that everything that needs to be improved must be assessed in order to identify the elements that are susceptible to change.

Evaluation, specifically educational evaluation, has been explored at different times and by different authors, including Scriven [1966], Casanova [1995], [1998], Lukas and Santiago [2004], and the Secretariat of Public Education [SEP] [2012].

Based on the studies carried out by these authors, we will delve a little deeper into the meaning of the term evaluation.

Educational evaluation 'applied to teaching and learning consists of a systematic, rigorous process of data collection, incorporated into the educational process from the outset, so that it is possible to have continuous, meaningful information to understand the situation, form value judgements about it, and make the appropriate decisions to continue the educational activity, improving it progressively' [Casanova M. A., 1995, p. 60].

It is also a rigorous and systematic way of obtaining information in order to have valid and reliable data about a situation with the aim of forming and making a value judgement about it. These assessments will enable the necessary decisions to be taken in order to correct or improve the situation being evaluated [Casanova M. A., 1998, p. 71].

Thus, according to the description provided by the Ministry of Public Education [2012], learning assessment is "the process that allows evidence to be obtained, judgements to be made and feedback to be provided on students' learning achievements throughout their education; therefore, it is an integral part of teaching and learning' [pp. 19-20]. It should also be understood as 'a process of recording information on the state of development of students' knowledge...whose purpose is to guide decisions regarding the teaching process..." [SEP, DGDC, & DGFCMS, 2012, p. 305].

At least to this point, we can identify the fundamental role of assessment in educational processes, both in teaching and learning.

However, what type of assessment should be developed in classroom work if it is conceived as "the process of identifying, collecting, and analysing relevant information—which may be quantitative or qualitative—in a systematic, rigorous, planned, directed, objective, credible, reliable and valid manner in order to make value judgements based on pre-established criteria and references to determine the value and merit of the educational object in question in order to make decisions that help to optimise the aforementioned object" [Lukas & Santiago, 2004, pp. 91-92], i.e., when the evaluation should be carried out and with what instruments to achieve the characteristics developed by the authors of reference.

The authors and the SEP itself have explained at least three types of assessment according to when they are carried out: diagnostic, formative and summative, each of which fulfils a function and has a defined purpose. We will discuss the first type of assessment in the following lines.

Diagnostic assessment and standardized tests

Diagnostic assessment is carried out prior to the start of a school year or a class or the development of a topic. Its purpose is to identify the knowledge, skills and attitudes that the student has for carrying out the task. It is "considered... as part of formative assessment... its objective is to establish a baseline of common learning" [Ministry of Public Education, 2012, p. 25].

In other words, it is to identify what the students have in common in terms of learning, in order to use this as a starting point for developing the subject matter. This allows for the achievement of new learning.

This is in line with Maria Antonia Casanova's [1995] definition of assessment based on its temporality and the development of initial assessment, in which she identifies the following features: when a student arrives at school for the first time.

Or when they start a new course or begin their school education, and when a specific learning process begins [the development of content, a new learning topic, among others]. The characteristic of this last feature is that the student is already engaged in school work, that is, in a learning process.

The above serves as a framework to justify the application of the exam referred to in this work, as the students were already in the learning process and the purpose of the exam was to ascertain the level of achievement in order to establish strategies for improvement.

I would like to point out that the exam was designed as a standardized exam, which seeks to identify the level of achievement in relevant aspects of learning.

In this regard, it is useful to refer to the meaning given by Demarchi [2020]: 'Standardised tests ... are comparative assessments ... used as standardized measurement instruments, applied jointly in several countries, selecting groups or grades of similar students' that 'collect information on conceptual and procedural learning in different areas' [p. 109], or as proposed by [Kuncel and Hezlett, 2007] cited by [Hernández, Ramírez & Gómez, 2018, p. 152] 'standardized tests are used to predict which students will be the most successful and will benefit most from higher education in different disciplines' but also 'standardized tests are useful predictors of a student's subsequent performance, they predict more accurately, show no bias and are not influenced by teacher advice' [Hernández, Ramírez, & Gómez, 2018, p. 153].

Legal basis

The Durango state government, through the Ministry of Education, based on the achievement rates of students at different educational levels, designed the Durango Educational Programme in line with the 2023-2028 State Development Plan. The State Plan sets out six priority areas, the first of which is 'A supportive, inclusive Durango with social welfare' [PED, 2023-2028, p. 69] is oriented towards social development and conceives children and young people as the present and future of the state. It therefore proposes to guarantee equitable and inclusive education to improve the employability of graduates.

The results of the National Learning Assessment Plan [PLANEA] prior to lockdown, which place the state at a level of achievement below the national average, were used to formulate this Plan. but also takes into account that these levels continue to be present after the lockdown resulting from the SARS-CoV 2 virus pandemic, which left an educational gap of approximately 7.9% due to exclusion, dropout and abandonment.

This plan outlines that: "The quality of education must improve significantly. The challenge is to ensure that all students have access to a comprehensive education and high standards of excellence. The quality gap between public and private schools will narrow, and teachers will be better trained and motivated." [Government of the State of Durango, 2023, p. 60]

For this reason, the guiding principles of the State Development Plan presented in Figure 1 are proposed.

Box 1



Figure 1

Guiding axes of state development

Source: State Development Plan 2023-2028

For the purposes of this work, only guiding principle No. 1, 'A supportive, inclusive Durango with social welfare' [Government of the State of Durango, 2023], is considered, along with objective 1.11, strategy 1.11.1, and lines of action 1.11.1.1 and 1.11.1.5, which read as follows:

"Objective 1.11. Increase the level of educational achievement of basic education students.

Strategy 1.11.1. Guarantee a comprehensive, inclusive, equitable, and relevant educational service.

Lines of Action:

1.11.1.1. Improve fundamental and priority learning in basic education.

1.11.1.5. Strengthen teaching practices." [Government of the State of Durango, 2023, pp. 102-103].

The above essentially aims to increase the level of educational achievement by guaranteeing educational services to improve fundamental and priority learning through the strengthening of teaching practices [Government of the State of Durango, 2023, pp. 102-103].

The State Development Plan [2023, p. 60], in its presentation of the axis ‘Durango: supportive, inclusive and with social welfare’, projects, through objectives and strategies related to education, a significant improvement in the quality of education in the state. To achieve this goal or purpose, it proposes that challenges must be overcome to enable universal access to comprehensive education with high standards of excellence, reduce the quality gap between public and private schools [RAE, Royal Spanish Academy, 2024], train teachers, and increase investment in education by implementing educational policies to ensure equity and access to education. All of the above is aimed at ensuring that Durango has an educated and competent population that drives the economic and sustainable development of the state.

In addition, the Plan itself has been designed to ensure that, through its eight thematic areas and 20 strategies, education in the state is a constitutional right that enables learning and, in this way, breaks down the barriers that generate inequality, poverty and the vulnerability that these two aspects bring with them. Derived from the State Development Plan, the Durango 2023-2028 Education Programme [PED 2023-2028] was designed [see image 2], which sets out five priority areas aligned with the specific objectives of the programme, whose general objective is stated as:

To guarantee the right to an excellent education centred on principles of equity, inclusion, interculturality and attention to diversity for the entire student population of Durango, in order to contribute to their comprehensive development and help them achieve maximum learning outcomes. [Durango Education Programme 2023-2028, 2023, p. 35]

Box 2

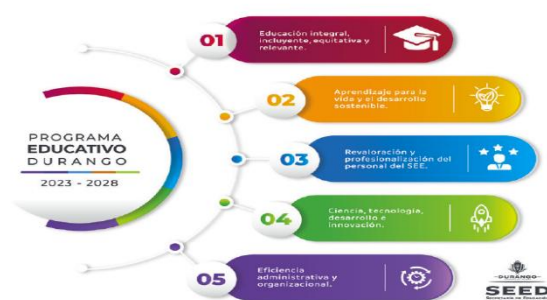


Figure 2

Priority axes of the EDP 2023-2028

Source: Durango Education Programme

In accordance with axis 1 of this educational programme, thematic line 1, ‘improvement of fundamental and priority learning’ [p. 42] and strategy 4 ‘Standardised state assessment’ [p. 46], the objective is to ‘Implement a standardized state assessment as a benchmark for improving teaching and learning in basic education’ [p. 46], the standardized state-level exam ‘2024 Learning Assessment’ was administered to propose alternatives to support teachers and students in reducing the academic gap between third and sixth grades of primary education. The purpose of the benchmark exam was stated as follows: ‘To identify the knowledge and skills acquired by third, fourth, fifth, and sixth-grade primary school students throughout the current school year in the areas of language and mathematics’ [2024 Learning Assessment, p. 2].

Methodology

The study was conducted using a quantitative, non-experimental approach at an exploratory, cross-sectional level, employing descriptive statistics, which, in the words of Orellana [2001], ‘descriptive statistics or exploratory data analysis offers ways of presenting and evaluating the main characteristics of data through tables, graphs and summary measures’ [p. 14].

For the analysis of the data, a sample of schools from school zone No. 128 was taken, using non-probabilistic sampling, which, among its advantages, allows ‘the researcher to obtain cases that are of interest and that offer a wealth of information for data collection and analysis’ [Hernández-Sampieri & Mendoza, 2018, p. 217]. Of the seven schools belonging to the school district, data were collected from the following: General Francisco Villa T. M. Primary School, General Francisco Villa T. V. Primary School, Silvestre Revueltas T. V. Primary School, and Carlos Marx T. M. Primary School. The first three are located in an urban area and the last in a rural area. It should be noted that they are representative of the population. ‘Silvestre Revueltas’ T. V. and Primary School ‘Carlos Marx’ T. M., the first three located in an urban environment and the last in a rural environment. It should be noted that they are representative of all the schools in the zone and that their enrolment represents around 65% of the school population in each of the grades in the School Zone.

The sample was selected for two main reasons: first, because the School Supervision Department needed data to identify the level of achievement in the school zone; and second, because the school principals allowed and facilitated the use of the exam answer sheets to analyse the results. The analysis presented here aims to provide an approximation of the level of achievement of the students so that the appropriate actions can be taken to increase it in the coming school years, addressing the particular needs of the groups and schools that allowed the use of the data.

As with all quantitative research, the variables that enabled the analysis to be carried out were taken. The variables defined are: Test item [numbered from 1 to 40 in grades three to five and from 1 to 38 in grade six], School, Grade, Group and Student number. Each of these variables was used to capture the data from the exam referred to in the first paragraph of the introduction to this paper.

The variable corresponding to the exam items is the variable that allows the results to be found and the achievement levels of each of them to be identified. These questions were grouped into three units of analysis: numbers and their operations, geometry and measurement, and data analysis or information management. Students had to use their knowledge and skills to solve them correctly, employing addition, subtraction, multiplication, or division, and in the case of sixth grade, fractions.

The school variable corresponds to the name of the school from which the data was recorded in order to control it and be able to establish the analysis as the results were obtained. The grade and group variables correspond to the school grade and the group being analyzed, as some schools have parallel groups labelled A or B. The student number variable corresponds to the records of all students in the sample. The folios of the answer sheets were used for this analysis, as that was all that was necessary. The aim of the analysis was not to make comparisons between students by gender or age.

The exam results were entered using Microsoft Office Excel. This process was carried out using the answer sheets corresponding to each of the students who took the exam, starting with the third grade and ending with the sixth grade.

Each mathematics exam had pre-determined answers, indicating that it was a multiple-choice exam in which students had to select the correct answer for each question. It should be noted that the third-grade exams, unlike those of other grades, which had four answers, only had three answers, of which only one was correct.

The student had to select the answer after reading the problem or statement presented in each of the questions that made up the exam.

Once the exam results had been recorded, the number of correct answers per question was counted, as well as the total number of correct answers obtained by each student. This allowed for statistical analysis using measures of central tendency. Since the aim was not to make generalisations, but only to find out the results of the examinations, the researchers decided to use only these measures to try to explain the results. The results were tabulated by grade and group, by school and for the entire sample, considering the percentage obtained per question and the score obtained per student.

Box 3

Table 1

Measures of central tendency for the analysis of the sample data

Measurement	3°	4°	5°	6°
Reagents	40	40	40	38
Mean	42	34.1	29.6	40.6
Median	43	30.9	27.5	38.1
Mode	#N/D	25.2	14.7	35.6
Minimum	16	14.5	4.9	11.0
Maximum	73	72.5	79.4	67.8

Source Own creation with Excel

Graphical results

Grade 3 results

Box 4

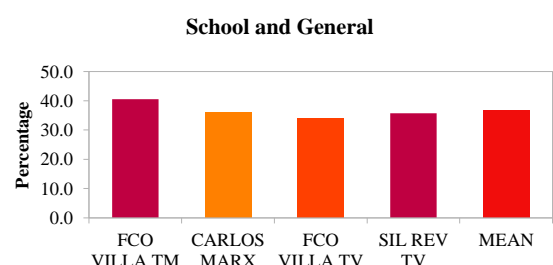


Figure 3

Overall hit rate

Source: Own creation based on analyzed data

Box 5

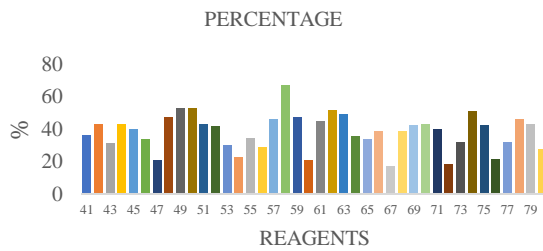


Figure 4

Percentage of achievement per item
 Source: Own creation based on analyzed data

Box 9

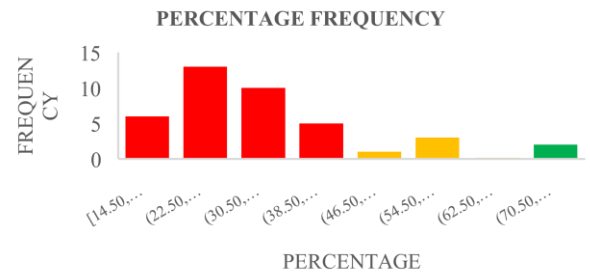


Figure 8

Percentage of pooled data
 Source: Own creation based on analyzed data

Box 6

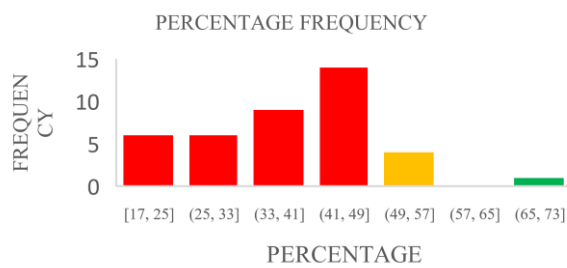


Figure 5

Percentage of pooled data
 Source: Own creation based on analyzed data

Fifth grade results

Box 10

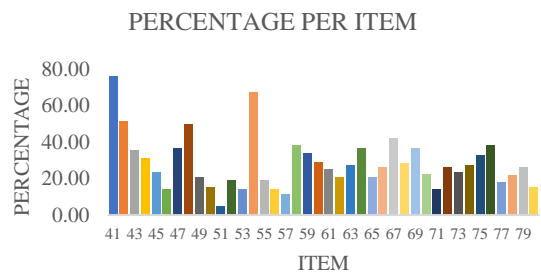


Figure 9

Overall hit rate
 Source: Own creation based on analyzed data

Fourth grade results

Box 7

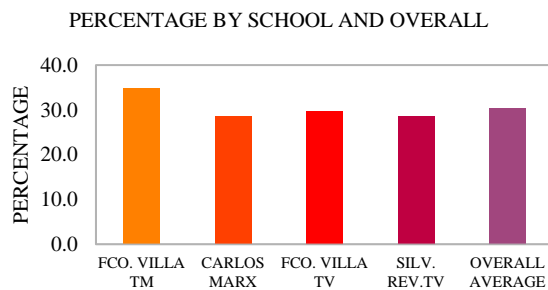


Figure 6

Overall hit rate
 Source: Own creation based on analyzed data

Box 11

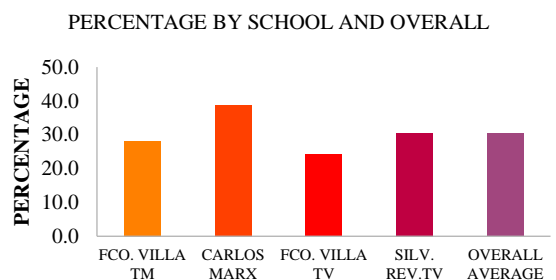


Figure 10

Percentage of achievement per item
 Source: Own creation based on analyzed data

Box 8

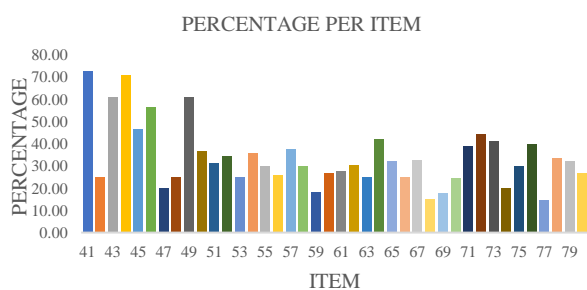


Figure 7

Percentage of achievement per item
 Source: Own creation based on analyzed data

Box 12

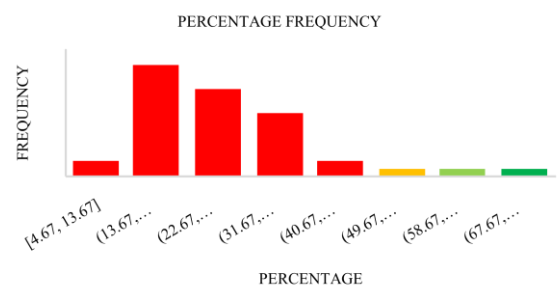


Figure 11

Percentage of pooled data
 Source: Own creation based on analyzed data

Sixth grade results

Box 13

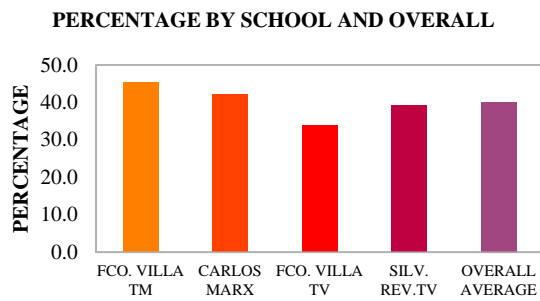


Figure 12

Overall hit rate

Source: Own creation based on analyzed data

Box 14

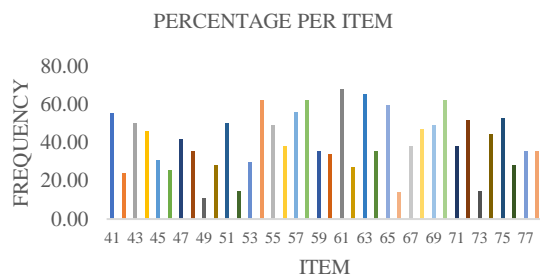


Figure 13

Percentage of achievement per item

Source: Own creation based on analyzed data

Box 15

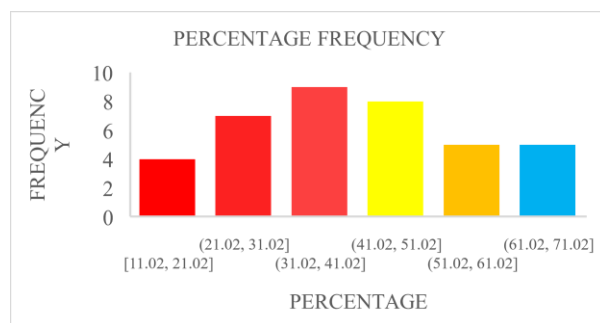


Figure 14

Percentage of pooled data

Source: Own creation based on analyzed data

Results

Assessment should always be considered an integral part of the teaching-learning process, as it provides data that, once analyzed, can be used to improve results, as suggested by the authors cited in the section on assessment.

The use of standardized tests provides a snapshot of the moment in which they are administered, but they also provide diagnostic elements that help teachers, school authorities and educational authorities in making decisions that focus on strategies aimed at improving learning. Once the areas with the greatest learning deficiencies have been identified, alternatives can be proposed to move along the path of continuous improvement, supporting students, teachers, and schools with materials, strategies, support, and advice to substantially increase student learning.

The Durango State government proposed the application of the exam in order to identify these gaps in students' knowledge, to develop a teaching strategy that would enable them to achieve lasting, meaningful and practical learning.

Undoubtedly, the results provide a great deal of information, which is why the analyses focused on the level of achievement of each grade in the sample schools, obtaining the results presented in Table 1 of this document.

There is no doubt that the results presented in the table are indicators of less than encouraging results in the learning process, as in all grades the average does not reach 50%. If we were to translate this to a grading scale of 5 to 10, the items, with the exception of those with the highest percentage, would be, so to speak, failed or without an adequate level of achievement.

However, it is also noteworthy that in Year 6, the number of questions with a percentage higher than 50 is greater than in the other years, which is possibly an indicator that students in this year have more cognitive tools to solve the exam they were given.

Conclusions

Assessment, whether carried out by internal or external evaluators, will always be an essential benchmark for improving the educational process, as stated by the authors referenced.

Even when standardized, assessment shows results that cannot be obtained simply by observing the group and recording their work, assignments, and so on. It is necessary to have a tool that encourages students to put their knowledge and skills into practice in solving problem situations that support them in making decisions in a real-life context.

Demonising standardized tests is akin to saying that teachers do nothing in the classroom. However, it should be remembered that there are many factors to be taken into account when creating a standardized test, as the teacher of the group does not participate in its development and application.

The standardized exam administered in April 2024 establishes some guidelines for analysis in order to make the necessary modifications to how students learn and what they learn, and how teachers teach and what they teach.

The analysis presented only emphasizes the achievement percentages of the questions that made up the exam. We believe that the next step is to identify the questions with the lowest achievement levels and identify what they were assessing in order to develop strategies that will improve teaching in this area of knowledge.

The assumption we made at the beginning is fully confirmed, as the results of the analysis show that there are indeed deficiencies in mathematics knowledge.

As for the purpose of the exam, we can also say that it was achieved, as it establishes the elements that need to be reviewed based on the questions in order to identify the conceptual and procedural knowledge that students should demonstrate in mathematics as part of their academic training.

Declarations

Conflict of interest

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

Contribution of the authors

Díaz-Ledezma, José de la Cruz: Contributed to the search for antecedents and theoretical references for the work, developing the theoretical section on assessment as well as the elements corresponding to the legal basis for the assessment and the theoretical basis for the methodology used in the analysis of the data, as well as the collection of the data.

Lino-Gamiño, Juan Alfredo: Performed the statistical analyses using descriptive statistics and Microsoft Excel software to develop the corresponding analysis tables and graphs.

Torres-Gutiérrez, Arturo: Was responsible for reviewing and editing the product presented here, taking into account the templates provided for the presentation of the work and writing the introduction to the document.

Availability of data and materials

Full availability of materials online. Any specific data can be requested by emailing jdelacruzdiazl@institutoeducativodoloresdelrio.edu.mx

Funding

No financial support was received.

Acknowledgements

No institution or company provided funding for this research; the costs were covered by the researchers.

Abbreviations

SEP	Ministry of Public Education
SEED	Durango State Ministry of Education
PLANEA	National Learning Assessment Plan
PDA	Learning Development Processes
PED	Durango Educational Programme
SARS-CoV-2	Severe Acute Respiratory Syndrome- Coronavirus 2 [virus that causes COVID-19]
CVU	Unique Curriculum Vitae [in CONAHCYT database]
DGDC	General Directorate for Curriculum Development
DGFCMS	General Directorate for Continuing Education for Teachers in Service
SNI-CONAHCYT	National System of Researchers - National Council for Science and Technology

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ISSN: 2523-2495.

RENIECYT: 1702902

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Discussions

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Bridges to STEAM: Effects of a micro-intervention on self-efficacy and gender stereotypes among female students in technical Upper-Secondary Education

Puentes hacia el STEAM: Efectos de una micro intervención en autoeficacia y estereotipos de género en mujeres de Bachillerato Tecnológico

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Classification:

Area: Social Sciences
Field: Education sciences
Discipline: Education
Subdiscipline: Comparative education

<https://doi.org/10.35429/JUM.2025.9.20.5.1.16>

History of the article:

Received: September 19, 2025

Accepted: December 10, 2025

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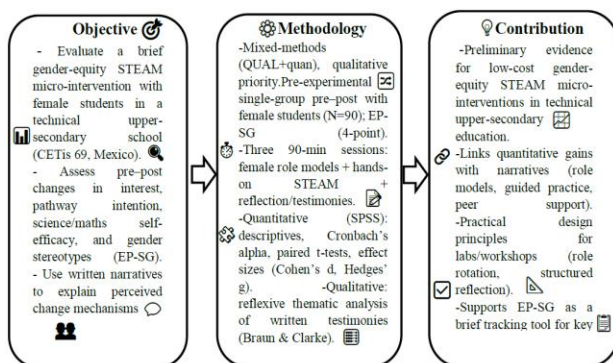


Abstract

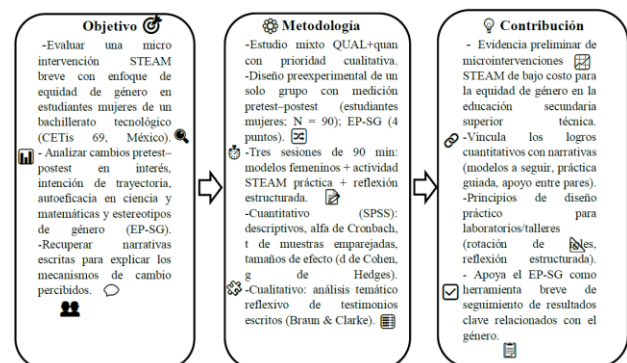
The present study evaluated a gender-equity STEAM micro-intervention with female participants in a technical upper-secondary school in Mexico. It used a mixed-methods design with a qualitative priority (QUAL+quan), as well as a pre-experimental one-group pretest–posttest scheme (N = 90). The EP-SG scale (1–4) was used to measure STEAM interest, pathway intention, science and mathematics self-efficacy, and gender stereotypes, where higher scores indicate lower acceptance of stereotypes. Significant increases were observed across the four subscales, with absolute $t(89)$ values between 4.87 and 5.92, $p < .001$, and moderate effect sizes ($d = 0.51–0.62$). Reflexive thematic analysis of written testimonies identified four central themes consistent with the quantitative findings. Overall, the results provide preliminary low-cost evidence to support the strengthening of STEAM pathways in technical upper-secondary education.

Resumen

En el presente estudio se realizó una evaluación sobre una microintervención STEAM con perspectiva de género a participantes mujeres de un bachillerato tecnológico en México. Se utilizó un diseño mixto con enfoque orientado a la parte cualitativa (QUAL+quan), además de un esquema preexperimental pretest-posttest con un solo grupo con N=90. Se utilizó la escala EP-SG (1-4) para realizar: la medición de interés por STEAM, intención de trayectoria, autoeficacia en ciencia y matemáticas y estereotipos de género donde los puntajes más altos indican una menor aceptación a estereotipos. Se observaron incrementos de manera significativa en las cuatro subescalas con valores absolutos de $t(89)$ entre 4.87 y 5.92, $p < .001$, además de tamaños de efecto moderados ($d = 0.51–0.62$). Para el análisis temático reflexivo de testimonios escritos se identificaron cuatro temas centrales coherentes con el resultado de los hallazgos cuantitativos. Con todo esto, los resultados aportan una evidencia de forma preliminar de bajo costo que ayuda a fortalecer trayectorias STEAM en educación media superior tecnológica.



STEAM education; Gender stereotypes; Self-efficacy



Educación STEAM; Estereotipos de género; Autoeficacia

Area: Development of strategic leading-edge technologies and open innovation for social transformation

Citation: Corral-Verdugo, Alex, Jiménez-López, Eusebio, Sepúlveda-Romo, Adrián and Lilia Zulema Gaytán Martínez. [2025]. Bridges to STEAM: Effects of a micro-intervention on self-efficacy and gender stereotypes among female students in technical Upper-Secondary Education. Journal University Management. 9 [20]1-16: e5920116.



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Introduction

The incorporation of women into activities related to STEM (science, technology, engineering, and mathematics) and also including the arts (STEAM) continues to be an ongoing challenge, despite international efforts in the area of gender equality. Recent literature confirms that even in modern times, the gender equality gap is a multifactorial phenomenon, which relates to various sociocultural, educational and even organisational dimensions, requiring the incorporation of more empirical evidence from different contexts. (Beroíza-Valenzuela & Salas-Guzmán, 2024; Joyce *et al.*, 2024; Altin & Yasan Ak, 2025).

Several authors agree that this disparity in gender equality is not the result of a single cause, but rather the correlation of several psychosocial processes, such as stereotypes related to the ingrained beliefs of those who belong to certain fields, risky academic climates, intrinsic biases in our society and cultural norms, which shape expectations and self-perceptions of competence.

In this regard, there is documentation that biases and the threat of stereotyping act as significant barriers to women's entry and retention in education systems, causing severe effects in fields such as engineering. In this regard, the importance of educational institutions as a fundamental space for peacebuilding and the active promotion of gender equality has been highlighted in recent times (Cheryan *et al.*, 2017; Casad *et al.*, 2019; Cadaret *et al.*, 2017; Zander *et al.*, 2020; Cech & Blair-Loy, 2019; Alzate Cardona *et al.*, 2025)

In the school environment, evidence confirms that the onset of interest in STEM careers and gender differences are shaped in a critical and important way during secondary school and sixth form. During this period, existing gaps can manifest themselves in specific experiences in classrooms and laboratories, expressed by differences associated with the time devoted to practical activities, perception of participation, and all the elements that can influence early vocational development in young people. (Balta *et al.*, 2023; Wang *et al.*, 2023; Fernández *et al.*, 2023; King & Pringle, 2019).

Based on a cognitive social culture, the most recent literature also suggests that there is a set of relationships associated with aspirations in STEM areas and that these depend largely on the self-efficacy that individuals tend to have in practical activities and on the expectations formed around the results obtained (Küçükaydın & Ulum, 2025; Moss-Racusin *et al.*, 2015; Charlesworth & Banaji, 2021). Moss-Racusin *et al.*, 2015; Charlesworth & Banaji, 2021).

In this regard, it has been reported that stereotypes can influence vocational interest in such a way that they can affect self-efficacy. For this reason, interventions that seek to expand boundaries in specific areas tend to be more consistent, as this occurs when mechanisms of representation and perception of ability are strengthened. (Luo *et al.*, 2021; Chan, 2022; Jiang *et al.*, 2024; Martín Carrasquilla *et al.*, 2023).

In response to all this, there has been an increase in interventions in the educational field, which are focused on reducing gaps, especially in school populations. Recent studies indicate that these strategies become more effective with the incorporation of active experiences and proper teacher support, as well as the addition of situations in which existing stereotypes are reinterpreted. Likewise, it has been observed that adding brief interventions, in conjunction with good design, can produce significant changes in adolescents' interest and self-efficacy. For this reason, the current literature emphasises the implementation of teaching strategies that take students beyond traditional teaching and incorporate assessment tools that promote active learning and scientific inquiry. (Prieto-Rodríguez *et al.*, 2020; Sáinz *et al.*, 2022; Yabaş *et al.*, 2022; Ford & dos Santos, 2024; Tulman *et al.*, 2025. ; Ruiz & García, 2025)

Despite all this, in Spanish-speaking contexts, particularly in countries such as Mexico, there is still a lack of evidence that considers aspects such as the educational environment and the promotion of professional identity building in the early stages. In educational systems such as technological secondary schools, academic training is developed using workshops, tools, and practices typically associated with men, which makes it especially relevant to understand how participation in these areas, self-efficacy, and the incorporation of women into technical areas are formed.

Therefore, more specific and regional evidence is needed on the training climate for women in technical fields and areas associated with engineering. (Hernández Herrera, 2022; Fernández-Cárdenas & Santillán-Rosas, 2025; Casad *et al.*, 2019; Harris, 2025; Master *et al.*, 2016).

In this context, this study conducts a retrospective analysis of the micro-intervention of bridges to STEAM with gender equality, implemented at the CETis 69 upper secondary school (located in Ciudad Obregón, Sonora), with the aim of estimating changes in key dimensions in: interest in STEAM, career intentions, self-efficacy in science and mathematics, and gender stereotypes. Therefore, quantitative evidence obtained through the application of the EP-SG instrument is integrated, incorporating written testimonies that allow for an estimation of the mechanisms perceived during the intervention from the participants' perspective.

Finally, this study contributes in three ways: (1) it provides evidence focused on upper secondary technological education, (2) it presents measurable results with narratives of experiences through a mixed-methods design with a qualitative emphasis, strengthening the interpretation of the findings, and (3) it yields practical results on the design of brief and effective strategies focused on strengthening self-efficacy, individual belonging, and intention that women may have in technical and engineering fields.

Methodology

Study design

A mixed study with a predominantly qualitative approach (QUAL+quan) was conducted. The quantitative component adopted a quasi-experimental design that includes the application of a pre-test and post-test with a single group, which is used to describe changes in scores on interest, career intention, self-efficacy, and gender stereotypes towards STEAM-related areas. This type of study is appropriate because it has been widely used in research that seeks to understand in depth both the effects that can be measured and the experiences of participants in STEAM-related activities with a gender perspective (Fredricks *et al.*, 2024; Fernández-Cárdenas & Santillán-Rosas, 2025; Sáinz *et al.*, 2022).

ISSN: 2523-2495.

RENIECYT: 1702902

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The qualitative component, which was the main focus of the interpretation, focused primarily on collecting brief narratives and written testimonies from students about their experience in the micro-intervention called 'Bridges to STEAM' with gender equality and their perceptions of women's participation in technical and engineering contexts.

The integration of both components is shown in the diagram in Figure 1, which illustrates the administration of the pre-test tasks, the development of the intervention, and, finally, the process of collecting quantitative and qualitative data.

Box 1

Mixed Methods Study with Qualitative Dominant Status (QUAL + quan)

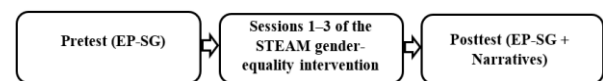


Figure 1

Mixed design with qualitative dominant status (QUAL + quan) from the study "Bridges to STEAM with gender equality"

Source: Own Elaboration

Context and participants

The study was conducted at the institution called "Centre for Industrial and Service Technology Studies No. 69" (CETis 69), which belongs to the technological upper secondary education system, within the framework of subjects related to engineering (mainly Mechatronics and Programming).

The instrument used was based on a non-probabilistic sampling approach for the convenience of this study, focusing on students who identify as women, for which the following criteria were used:

Be enrolled at CETis 69 in the semester in which the instrument was applied.

Be taking at least one technical subject associated with the field of engineering.

Agree to participate voluntarily in the entire intervention.

The final sample consisted of 90 female students, aged between 15 and 17 ($M = 16.03$, $SD = 0.71$), distributed by technical specialities, of which 42.2% were studying programming ($n = 38$) and 37.8% mechatronics ($n = 34$). In addition, 20.0% were studying other technical specialities ($n = 18$). Similarly, it is mentioned that, of the sample population, 41.1% were in their third semester ($n = 37$), 40.0% in their second semester ($n = 36$), and 18.9% in their fourth semester ($n = 17$), all of which is represented in Table 1.

Box 2

Table 1

Distribution of the sample by speciality, semester, shift and age.

Variable	Category / statistician	n	%
Age (years)	$M = 16.03$; $DE = 0.71$; rango = 15–17	90	100
Technical speciality	Programming	38	42.2
	Mechatronics	34	37.8
	Other technical specialities	18	20
Semester taken	Second semester	36	40
	Third semester	37	41.1
	Fourth semester	17	18.9
Shift	Morning	60	66.7
	Afternoon	30	33.3

Note. $N = 90$ female students. No missing data were recorded in the characterisation variables. $M =$ mean; $SD =$ standard deviation.

Source: Own Elaboration

Quantitative instrument: EP-SGr

For the quantitative component, the STEAM Bridge Scale with Gender Perspective (EP-SG) questionnaire was used. The instrument includes: A sociodemographic section containing: age, semester, specialisation, and shift.

Four 4-point Likert-type subscales (1 = Strongly disagree; 4 = Strongly agree):

Interest in STEAM (4 items): assesses liking, curiosity, and enjoyment of science, technology, engineering, arts, and mathematics activities and content.

STEAM career intention (4 items): explores future willingness to choose subjects, projects, careers, or jobs related to STEAM areas.

Self-efficacy in science and mathematics (4 items): measures the belief that, with study and effort, students can understand and solve science and mathematics content.

Gender stereotypes in STEAM (6 items): investigates beliefs about supposed male superiority in technical fields and those associated with engineering. Three items written in a stereotypical sense (e.g., engineering is more for men than for women, etc.) were recoded so that higher scores reflect less stereotyping and a greater orientation toward gender equality.

The mean scores for each subscale were calculated from the items. Internal consistency was assessed using Cronbach's alpha coefficient in the pretest data, with values equal to or greater than 0.70 considered acceptable. Table 2 summarises the structure of the assessment instrument, the number of items per subscale, an example of an item, the score range, and the values obtained with Cronbach's alpha.

Box 3

Table 2

Structure of the STEAM Bridge Scale with Gender Perspective (EP-SG) and internal consistency in the pretest ($n = 90$)

Subscale	N.º of items	Example item	Score range	Cronbach's alpha (pre-test)
Interest in STEAM	4	"I like activities that combine science, technology and creativity."	4–16	0.899
STEAM trajectory intention	4	I would like to study a degree related to science, technology or engineering.	4–16	0.935
Self-efficacy in science and mathematics	4	"If I study hard, I can understand maths and science topics."	4–16	0.897
Gender stereotypes in technical fields (reversed)	6	Men are better than women at mechanics and programming.	6–24	0.941

Note. The items shown are answered on a 4-point Likert scale (1 = 'Strongly disagree', 4 = 'Strongly agree') where the subscale scores correspond to the total sum of the items. In the case of the gender stereotypes subscale, previously recoded items were used, such that higher scores show or indicate less agreement with stereotypes and a greater orientation towards gender equality.

Source: Own Elaboration

Qualitative component: narratives and written testimonies

The qualitative component was integrated through a block of open-ended questions and a written reflection activity at the end of the micro-intervention. In addition, students were asked to write short narratives in which they:

- Described significant previous experiences related to science, technology or STEAM-related projects;
- They expressed their perceptions of the presence and role of women in technical and engineering fields;
- They noted perceived changes in their interest, self-efficacy, and intention to continue training in STEAM fields after the intervention;
- They commented on which activities in the module they found most meaningful and why.

Description of the micro-intervention

The micro-intervention, called 'Bridges to STEAM with gender equality', was implemented in the Mechatronics Workshop and in the laboratory at the end of the course and was structured in three sessions of approximately 90 minutes each:

Session 1 - Visualisation and female role models in STEAM activities:

A brief presentation was given on the gaps that exist in technical and higher education, accompanied by brief examples from Mexican and international female engineers and scientists. This activity included thought-provoking questions and a guided discussion on existing gender stereotypes and the personal experiences of the students.

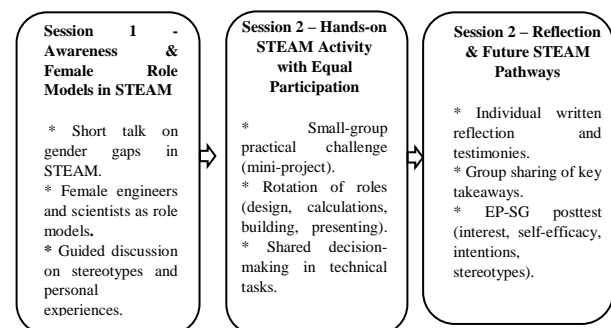
Session 2 - Practical STEAM activity with a focus on equality:

To carry out this activity, a practical exercise was conducted, which consisted of developing a technical idea that would test their creativity and problem-solving skills or, in the case of mechatronics, designing a simple prototype. In addition, equal participation was promoted through the rotation of roles such as design, calculation, execution, presentation, and shared decision-making.

Session 3 – Reflection and future outlook: The experience was concluded with an activity involving both individual and group reflection, in which the students wrote testimonials about the intervention, expressed their interest in continuing with STEAM-related activities, shared their views on the role of women in these fields, and completed the EP-SG post-test questionnaire. The general structure of the micro-intervention is shown in Figure 2.

Box 4

Structure of the Bridges to STEAM with Gender Perspective Scale (EP-SG)



Note: EP-SG = Bridges to STEAM with a Gender Perspective Scale

Figure 2

Structure of the micro-intervention "Bridges to STEAM with a gender perspective."

Source: Own Elaboration

Procedure

The study adhered to the ethical guidelines and regulations of the institution. The procedure was as follows:

1. The management and authorisation of CETis 69 and the corresponding academic coordination were carried out.
2. The objective of the study, the confidentiality of the data, and the importance of participation were communicated to the students. Due to the presence of minors, the data was treated in accordance with institutional procedures for minors, and a report on the activity was provided to the parents.
3. At the beginning of the intervention, a pre-test was administered in Google Forms format, which lasted 10-15 minutes.

4. Subsequently, three micro-intervention sessions were conducted in accordance with the aforementioned plan.
5. After the last session, the post-test of the EP-SG questionnaire was administered, incorporating the block of open-ended questions and the written reflection activity.
6. All the responses obtained were exported to a spreadsheet for subsequent processing using SPSS software version 27. In addition, testimonies and narratives were organised using matrices for qualitative analysis.

Data analysis

Quantitative component

For the statistical processing of the data, subscales such as the mean and standard deviations were calculated during the pre-test and post-test, and Cronbach's alpha was used to measure their reliability. On the other hand, to assess the changes associated with the intervention, 't-tests' were applied to the samples related to the pre- and post-mean scores of the four subscales used, which are: interest, career intention, self-efficacy, and gender stereotypes. Furthermore, the effect size (Cohen's d) was calculated with 95% confidence intervals in order to quantify the practical magnitude of the changes observed.

Qualitative component

The qualitative treatment of the information was carried out following the proposals of: Braun & Clarke, 2006; Braun & Clarke, 2022, which cover aspects such as familiarisation with the data, the generation of initial coding, the search for themes, etc. Themes were identified that relate to:

- a. Perceived changes in interest, self-efficacy, and intention to pursue STEAM fields.
- b. Reinterpretation of gender stereotypes and perception of female role models in technical contexts.

The quantitative and qualitative results were integrated into the discussion using complementary triangulation, where numerical data was used to contextualise and reinforce the interpretations constructed from the students' narratives.

Results

Sample characteristics

During the study, 90 students participated, all of whom were female upper secondary school students from CETis No. 69. The average age of these women was 16.03 years (SD = 0.71; ranging from 15 to 17 years). The vast majority of the sample under study was enrolled in the Programming and Mechatronics specialisations. However, other technical courses were also represented, accounting for a smaller portion of the sample, mainly from the first and third semesters. Likewise, more than two-thirds of the participants were in the morning shift and the rest in the afternoon shift, with a detailed distribution by specialisation, semester and shift as shown in Table 3.

Box 5

Table 3

Sociodemographic characteristics of participants (N = 90)

Variable	Category	n	%	Media	DE	Range
Age in years	—	90	100	16.03	0.71	15–17
Technical speciality	Mechatronics	34	37.8	—	—	—
	Programming	38	42.2	—	—	—
	Other	18	20	—	—	—
Semester completed	2.º	36	40	—	—	—
	3.º	37	41.1	—	—	—
	4.º	17	18.9	—	—	—
Group turn	Morning	60	66.7	—	—	—
	Afternoon	30	33.3	—	—	—

Source: Own Elaboration

Psychometric properties of the EP-SG

The use of the Bridges to STEAM with a Gender Perspective Scale (EP-SG) consisted of four subscales, which are: 1) interest in STEAM, 2) intention to pursue a STEAM career, 3) self-efficacy in science and mathematics, and 4) gender stereotypes in STEAM (these items were recoded so that higher scores indicate less agreement with stereotypes).

For each subscale, the mean of the corresponding items was calculated, with a typical theoretical range of 1 to 4 points (where 1 = strongly disagree and 4 = strongly agree). For the reliability analyses, Cronbach's alpha coefficients were reported in a high range for all the aforementioned subscales, from the pretest to the posttest. These values are within the expected range for educational studies of this type with Likert scales (see Table 4). The results indicate adequate and correct internal reliability for the use of the EP-SG instrument in this female technological high school student population.

Box 6

Table 4

Structure and internal consistency of the STEAM Bridge Scale with a Gender Perspective (EP-SG)

Subscale	No. of items	Example item	Score range *	Cronbach's alpha (pre-test)
Interest in STEAM	4	"I enjoy participating in activities related to science or technology."	1–4 (media)	0.899
STEAM trajectory intention	4	"I would like to study a degree related to engineering or technology."	1–4 (media)	0.935
Self-efficacy in science and mathematics	4	"If I study, I can understand maths topics, even if they are difficult."	1–4 (media)	0.897
Gender stereotypes in STEAM (R)**	6	Engineering is just as suitable for women as it is for men.	1–4 (media)	0.941

Source: Own Elaboration

Pre-post changes in the EP-SG subscales

To quantify the impact of the micro-intervention carried out, a comparison was made of the mean scores obtained for each subscale of the EP-SG instrument before and after the intervention using paired t-tests. An increase in the means obtained from the pre-test and post-test of the cases analysed was observed, and statistical significance was obtained in the data obtained and effect sizes in a moderate proportion.

For the STEAM interest subscale, a score was obtained where the mean increased from 2.59 (SD = 1.07) during the pretest to 2.91 (SD = 1.09) for the posttest, $t(89) = -5.92$, $p < .001$, with a Cohen's effect size d of 0.62. For the STEAM career intention subcategory, the mean increased from 2.48 (SD = 1.19) to 2.81 (SD = 1.15), $t(89) = -5.73$, $p < .001$, $d = 0.60$. Based on these data, it is reasonable to suggest that, after completing the micro-intervention, the students not only reported greater interest in STEAM activities, but also showed a greater willingness to consider future studies or career paths related to these areas.

In the case of self-efficacy in science and mathematics, the mean increased from 2.49 (SD = 1.08) in the pretest to 2.79 (SD = 1.10) in the posttest, $t(89) = -4.87$, $p < .001$, $d = 0.51$. This confirms that there was a significant increase of moderate magnitude in the perception of ability to understand and deal with science and mathematics content.

Finally, for the STEAM gender stereotypes subscale (which was recoded so that higher values indicate less agreement with stereotypes), the mean score increased from 2.79 (SD = 1.06) to 3.06 (SD = 0.96), $t(89) = -5.20$, $p < .001$, $d = 0.55$. These data indicate a significant reduction in the acceptance of gender stereotypes linked to STEAM after the micro-intervention (see Table 5). It should be noted that the negative sign of ' t ' reported is due to the fact that the comparison made was defined as pretest minus posttest, while for effect sizes ' d ' a positive value is considered for easy interpretation in the study (obtaining favourable increases between the initial and final measurements).

Box 7

Table 5

Pre–post comparison on the EP-SG subscales (means, SD, t , p , and Cohen's d)

Subescala	Pre, M (DE)	Post, M (DE)	$t(89)$	p	Cohen's d
Interest in STEAM	2.59 (1.07)	2.91 (1.09)	-5.92	< .001	0.62
Intention to pursue a STEAM career	2.48 (1.19)	2.81 (1.15)	-5.73	< .001	0.6
Self-efficacy in science and mathematics	2.49 (1.08)	2.79 (1.10)	-4.87	< .001	0.51
Gender stereotypes in STEAM	2.79 (1.06)	3.06 (0.96)	-5.2	< .001	0.55

Source: Own Elaboration

Qualitative results

For the reflective analysis of the written testimonies in the study, four central themes were identified, which are considered: (1) reframing STEAM as an accessible and achievable option, (2) strengthening self-efficacy in science and mathematics, (3) questioning gender stereotypes in STEAM, and (d) the relevance of female role models and teacher support. These themes emerged inductively from the students' written testimonies, and finally, a relationship was sought with the quantitative subscales for the EP-SG instrument, as shown in Table 6.

Box 8

Table 6

Emerging themes and sub-themes in testimonials about the micro-intervention Bridges to STEAM with gender equality

Subject	Main subtopics	Description of the topic	Illustrative citation example*
Reframing STEAM as an accessible and achievable option	Discovering new STEAM areas: the connection with everyday problems	Students go from perceiving STEAM as something very distant or "only for very intelligent people" to recognising it as diverse fields that are useful and related to real scenarios in their social environment.	I used to see engineering-related courses as something very complicated or unrelated to me, but now I see that they are more relevant to my life and school than I thought. (Student 14, 3rd semester)
Strengthening self-efficacy in science and mathematics.	Perception of ability to resolve difficult content. Confidence to participate and ask questions	There is a noticeable increase in student confidence in relation to learning science and mathematics, taking on more technical challenges and participating in laboratory, classroom and school activities.	I had always struggled with mathematics, but in the projects I was assigned, I felt that I could contribute something valuable. Being able to take things step by step and work as a team with my classmates filled me with confidence in myself and my abilities. (Student 07, 5th semester)
Challenging gender stereotypes in STEAM	Identification of previous sexist messages. Criticism of the idea that technical careers "are solely and exclusively for men".	Students identify phrases and attitudes or situations that they previously saw as just a joke or normal, and now begin to question the idea that STEAM careers are only reserved for men or people who identify with that gender.	In my family, it is said that mechanics is only for men. Previously, I didn't say anything about this, but now I think that as a woman I can also study mechanics or careers such as mechatronics and that I am also capable of doing well. (Student 41, 3rd semester)
Relevance of female role models and teacher support	Visibility of women in STEAM Assessment of the climate of respect and listening towards science and mathematics	Learning about the stories of women involved in STEAM and having a safe and supportive space is seen as a key and essential factor in imagining one's own career paths in these fields.	It was motivating to meet and see examples of women who have already gone through what we are going through and are now working on important things. This makes you think that you can do what you like or what appeals to you. (Student 19, 3rd semester)

Source: Own Elaboration

Reframing STEAM as an accessible and achievable option

The first theme refers to a change in the students' perception and their view of STEAM. The comments show that the students associate highly complex areas of knowledge with highly qualified people or with men only. However, after the three sessions, their thinking changed favourably, with very positive reactions towards STEAM and related fields, which they now perceive as more accessible and associate with their everyday reality.

The practices and activities carried out in the mechatronics and ICT workshops stand out as activities that strengthened their confidence and understanding in the application of science and technology, as well as helping them to understand that STEAM is not limited or restricted to sitting in front of a computer, but that these practices help to solve everyday problems at school or in the community.

Comments such as: *I used to see engineering careers as something very complicated or unrelated to me, but now I see that they are more related to my life and school than I thought. (Student 14, 3rd semester).*

This whole process of reframing is consistent with the increases observed in the scales used to measure interest and intention in STEAM trajectories in EP-SG.

Strengthening self-efficacy in science and mathematics

The second theme is associated with the strengthening of perceived self-efficacy in science and mathematics, where participants describe that, during the micro-intervention, they felt capable of tackling tasks that normally caused them some kind of insecurity. This became more evident when a clearer and more in-depth explanation was provided, complemented by guided examples and the participation of their classmates.

The participants' narratives highlight the collaboration and rotation of roles in the different activities proposed, as well as the conditions that contributed to the active participation of all students during the practical sessions.

Taking on a specific role allowed them to experience a more active contribution to tasks that they had previously avoided, especially in activities associated with calculations or the use of technological tools. The following quote confirms the above:

Quote: *I had always struggled with mathematics, but in the projects I was assigned, I felt that I could contribute something valuable. Being able to go step by step and work as a team with my classmates filled me with confidence in myself and my abilities. (Student 07, 5th semester).*

The pattern observed in the change in narratives indicates that the pedagogical mechanisms that underpin this change, such as scaffolding, guided practices, and peer support in the proposed activities, behave consistently and effectively with the expected results.

Questioning gender stereotypes in STEAM

The third theme considered is the normalisation of questioning gender stereotypes linked to STEAM. In the testimonies collected, the students mention comments associated with all kinds of stereotypes, such as that women are not good at mechatronics, or that careers in mechanics or related fields are only for men. Prior to the intervention, these stereotypes were interpreted as jokes or as unwritten rules that always had to be followed.

Based on the discussions presented in session one and also on the presentation of data related to gender gaps, the participants mentioned that all of the aforementioned stereotypes can cause discouragement among women in remaining in or entering STEAM careers. In addition, some students indicated that these types of stereotypes are still present, however, they now have solid arguments to challenge them effectively.

Textual comment from student 41, 3rd semester: *In my family, they say that mechanics is only for men. I didn't say anything about this before, but now I think that as a woman I can also be in mechanics or careers such as mechatronics and that I am also capable of doing it well.*

Questioning these types of stereotypes is consistent with the increase in scores associated with the EP-SG's STEAM gender stereotypes subscale (where a higher value indicates less agreement with stereotypes), suggesting that during the intervention, it serves as a mechanism for critical reflection on the impact of sexist messages on academic decisions.

Relevance of female role models and teacher support

The fourth topic evaluated discusses the importance of highlighting female role models in STEAM and the type of teacher support used in the intervention. It is possible to observe that the participants greatly valued learning about some success stories of women associated with technical careers, such as scientists or engineers, with a recognised track record and working in relevant areas. This is demonstrated as a role model, which allows them to imagine themselves in possible careers beyond the stereotypes that exist.

The students describe the space provided by the micro-intervention as an environment that promotes their safety, where they were also able to express their doubts and share experiences of insecurity or discrimination. In short, several suggest promoting activities such as those described above, towards a culture and promotion of science and technology in technological secondary schools, as can be seen in the following comment from student 19, 3rd semester: *It was motivating to meet and see examples of women who have already gone through the same thing we are going through and who now work on important things. This makes you think that you can do what you like or what catches your attention.*

This topic associates changes in interest, intention and self-efficacy with relational and contextual components. STEAM trajectories are not only built on individually focused attitudes, but also on having female role models, as well as on the perceived climate in the classroom and the support that teachers can offer.

Integrated synthesis of quantitative and qualitative results

In summary, both the quantitative and qualitative results observed indicate a pattern in relation to the impact of the micro-intervention carried out by STEAM bridges with gender equality on the group of participants under study. The EP-SG instrument scores reveal statistically significant increases of moderate magnitude in the four subscales analysed: interest, intention to pursue a STEAM career, self-efficacy in science and mathematics, as well as, as expected, a lower acceptance of gender stereotypes between the pre-test and post-test. These results suggest a consistent improvement in the participants' attitudes, expectations, and beliefs regarding STEAM areas after the intervention.

On the other hand, the qualitative component contributes by providing detailed explanations for these changes. The participants' narratives reframe STEAM areas as a reliable and safe option, as they show greater confidence when facing scientific or mathematical content, question traditional stereotypes that they previously considered normalised, and greatly value having female role models, as well as the teaching support that can be provided to them. It is also worth mentioning that all these findings reaffirm the trends observed in the scores of the instruments applied and also help to better understand the subjective and relational processes associated with these areas.

In summary, it is possible to mention that carrying out a brief micro-intervention such as the one applied, which combines practice and safe spaces for critical gender reflection, has a very positive effect on bringing women closer to areas related or similar to STEAM. This opens up a wide range of possibilities for the use of long-lasting strategies with a focus on gender equality in technical education.

Conclusions

The objective of this study was to assess the effect of a micro-intervention on the study group from a gender perspective, in aspects such as attitudes and beliefs related to STEAM-related areas in technological high school students, integrating both quantitative and qualitative evidence.

Overall, the findings suggest consistent improvements in the four dimensions assessed by the EP-SG instrument used, with statistically significant pre-post differences and moderate effect sizes (d between 0.51 and 0.62 respectively). In addition, the internal consistency reported for the subscales considered confirms that the changes observed are estimated with acceptable accuracy in this sample.

Changes in interest and career intention, from something distant to a viable option

The increase in interest in STEAM and in STEAM career intention observed after the intervention is consistent with the idea that vocational orientation in STEM depends not only on individual preferences, but also on access conditions, close experiences, and environmental cues about who 'belongs' in these fields. Recent literature reports gender differences in interest in STEM career paths in secondary education, and it has been emphasised that such differences are partially explained by psychosocial variables (e.g., beliefs about ability, outcome expectations, and contextual factors). Along the same lines, the weight of the 'perceived climate' and available support appears to be a key element in enabling students to translate their interest into a realistic intention to continue.

Qualitative results reinforce this interpretation: the theme of reframing STEAM as a close and achievable option indicates a shift from perceptions of distance to a more everyday, applicable, and 'possible' reading of STEAM areas. This correlation between numerical change and giving meaning to the narrative suggests that the micro-intervention used not only increases scores but also refocuses the meaning of STEAM and generates a connection with the daily lives of the participants, which is relevant because it is the mechanism for consolidating vocational decisions at an early stage.

Self-efficacy as a central mechanism: the role of guided experience and collaborative work. The increase in self-efficacy in science and mathematics is a particularly valuable finding because evidence indicates that self-efficacy functions as an explanatory pathway between stereotypes and expectations and interest in STEM trajectories.

For example, it has been documented that STEM stereotypes can predict career interest through self-efficacy and outcome expectations. In your study, the narratives describe very specific pedagogical conditions associated with increased confidence: step-by-step explanation, guided examples, collaboration, role rotation, and active participation.

These descriptions lend plausibility to quantitative changes by suggesting that the increase in self-efficacy was not abstract, but supported by structured experiences that reduce the perceived threat of “difficult” tasks and normalise supported learning. This point matters because self-efficacy is often a robust predictor of engagement and persistence in STEM; therefore, brief interventions that succeed in raising it can be strategic in technical education contexts, where contact with technological and problem-solving activities can become a confirming event (I can do it, I understand, I belong).

Less acceptance of stereotypes and signals from the educational environment. Regarding the STEAM gender stereotypes subscale, the results concerning the increase in scores between the pre-test and post-test suggest that there is a reduction related to the level of acceptance of stereotypes after the end of the intervention.

This evidence is considered relevant because gender stereotypes in STEAM are widely documented in school environments, allowing this problem of attitudes to be addressed at an early age and thus avoiding limitations on aspirations and vocational relevance. Furthermore, when female students perceive signs of exclusion or non-belonging in their environment (e.g., in areas such as computing), their interest tends to decline, not necessarily due to a lack of ability, but rather due to cultural and/or symbolic messages associated with the field of study.

The qualitative component complements this finding by explicitly identifying the questioning of stereotypes as one of the emerging themes, suggesting that the change was not only attitudinal but also discursive, as participants were able to name, discuss or challenge previous assumptions.

From an educational perspective, this is particularly important because evidence shows that exposure to information or evidence causes a change in attitudes and behaviour, although this depends on the context and the way in which it is presented. Female role models and teacher support.

The fourth theme identified is that of female role models and teacher support, which provide a broader view of the relevance of STEAM trajectories, telling us that they are constructed using the relational part with the environment and the contextual part, all of this not only from the individual motivations of the individual but also from that set of attitudinal factors.

This reinforces the idea of the existing need to use school interventions aimed at girls from early school levels as a strategy to generate greater participation and aspirations in STEAM areas. Furthermore, the presence of female role models, together with active teacher support, operates in such a way as to send signals of belonging and validation to these variable models, which in turn reinforce interest and self-efficacy, which in turn favour intentions to continue.

Implications for technical secondary education. The results obtained suggest that the application of brief micro-interventions combined with spaces for critical reflection and guided activities is an effective strategy in technical secondary schools where curriculum time is short and limited.

It should also be mentioned that the combined pattern of improvements in interest, self-efficacy, and lower acceptance of stereotypes supports the relevance of incorporating three components of future actions, which are: (1) properly structured practical experiences that allow for early achievements, (2) visibility of female role models and references, and (3) proper teacher support that fosters a positive classroom environment and everyday language.

Limitations and lines of continuity

The study has limitations that must be considered when interpreting the findings, including the following:

- a) The limitation of the pretest-posttest design prevents the attribution of causality with the same impact as if there were a comparison group design, which is why the idea that factors such as history, maturation, or the measurement effect may influence the results cannot be ruled out. In addition, the qualitative information comes from very brief testimonies, which encourages active participation by individuals but, on the other hand, limits the depth of interpretation compared to other instruments such as interviews or focus groups.
- b) It should also be noted that the study was conducted in a very specific institutional context, which is why it is highly advisable to replicate it in other institutions and carry out temporary follow-ups to assess the stability of the change.
- c) As a follow-up, it is advisable to implement a design with a comparison group and also follow-up measurements, such as weeks or months after application, to assess permanence.
- d) Modelling the variables in greater detail is another aspect that must be considered, for example, whether the reduction in stereotypes and an increase in self-efficacy explain an increase in career intention, given that the literature effectively points to structural links between these dimensions.
- e) Another line of inquiry is to model the relationships between variables in greater detail (for example, whether the reduction in stereotypes and the increase in self-efficacy explain the increase in career intention), given that the literature points to structural links between these dimensions.

Final conclusions

In short, with all the evidence gathered, it should be noted that the micro-intervention Bridges to STEAM with gender equality is a promising strategy for promoting attitudes and beliefs in favour of STEAM among technological high school students, especially because it strengthens self-efficacy, redefines the proximity that may exist towards STEAM, and encourages questioning of existing stereotypes.

The results obtained provide valuable evidence for the redesign of brief, replicable interventions adapted to the desired context, which will have the potential to increase female participation in technical and engineering careers.

Annexes

Box 9

Table 7

Operational specification of the STEAM Gender Equality Bridge Scale (EP-SG): subscales, recoding, and scoring rules

Subscale	No. of items	Example item (abbreviated text)	Recoding	Range (average, 1-4)	Rank (amount)	α (pre-test)
Interest in STEAM	4	I like STEAM activities.	Not applicable	1-4	4-16	0.899
Intention towards STEAM	4	I would like to study a degree related to STEAM in the future.	Not applicable	1-4	4-16	0.935
Self-efficacy in STEAM	4	I consider myself to be good at STEAM subjects and activities.	Not applicable	1-4	4-16	0.897
Gender stereotypes	3	Men are better at mechanics and programming.	Yes: new = 5 - original response	1-4	3-12	0.941
Scoring rule	15 (total)	The subscale score was calculated as the mean of its items (1...ions; the sum is equivalent and is reported as a theoretical range.	Apply Recoding only to stereotypes before averaging /summing.	—	—	—

Source: Own Elaboration

Box 10**Table 8**

Guide to open-ended questions (written reflection after intervention) and link to EP-SG dimensions

Dimension of reflection	Open-ended question for reflection (suggested text)	Link to EP-SG
Identification with STEAM	Write a brief experience or story that made you feel connected to STEAM (science, technology, engineering, arts, and mathematics).	Interest in STEAM
Perceived efficacy and interest	Describe a situation in which you felt capable and interested in doing a STEAM activity. What happened and what helped you achieve it?	Self-efficacy in STEAM; Interest in STEAM
Aspirations and career choice	What would you like to study or what would you like to do in the future? Explain why and whether you are interested in it being related to STEAM.	Interest in STEAM
Identification with STEAM	Write a brief experience or story that made you identify with STEAM (science, technology, engineering, arts, and mathematics).	Interest in STEAM
Perceived efficacy and interest	Describe a situation in which you felt capable and interested in doing a STEAM activity. What happened and what helped you achieve it?	Self-efficacy in STEAM; Interest in STEAM

Source: Own Elaboration

Declarations**Conflict of interest**

The authors declare that they have no conflicts of interest.

Author contribution

Corral-Verdugo, Alex: Conceptualisation, methodology, research, statistical data processing, formal analysis, visualisation, drafting of the original manuscript, overall project management and administration. Led the mixed design (QUAL+quan) and implementation of the micro intervention, coordinated the application of pre- and post-tests, organised the database for analysis in SPSS v27 software and qualitative matrices, performed quantitative analyses (reliability and pre-post comparisons) and thematic analysis of testimonials, and drafted the first version of the manuscript.

Jiménez-López, Eusebio: Methodology, Resources, Research, Support in data curation, Model validation, Writing: review and final editing of the document. He contributed to the refinement of the EP-SG instrument and application inputs, supported implementation in the school context and the systematisation of responses (quantitative and narrative), collaborated in the curation/organisation of data for analysis, and reviewed the manuscript to ensure pedagogical alignment and internal consistency of the report.

Sepúlveda-Romo, Adrián: Support in methodology, resources, research, validation, writing: review and final editing. Supported operational planning and the development of teaching resources for the micro-intervention sessions, collaborated in the collection of field information (instrument and testimonies), verified the integrity of the records captured before their processing, and contributed substantive revisions to improve the clarity and coherence of the manuscript, and provided the necessary support to the entire team.

Gaytán Martínez, Lilia Zulema: Literature review, article writing, reviewed questionnaires and participated in the development of teaching resources for micro-intervention sessions, contributed substantive revisions to improve the clarity and coherence of the manuscript, and provided necessary support to the entire team.

Luna-Bracamontes, Alberto: Resources, research, supervision, validation of resources, writing, review and editing of materials. He supported the management within the institution for the correct implementation of the intervention (access, logistics, and coordination with the different school actors), in addition to supervising the correct execution of the instrument application protocol, verifying the consistency of the records before analysis, and conducting critical reviews of the manuscript to improve clarity, coherence, and alignment with the educational context.

Availability of data and materials

The data and analysis materials (CSV/Excel, etc.) will be openly available on Zenodo, and the DOI will be provided upon publication of the article.

Funding

This research received no external funding.

Acknowledgements

The authors would like to thank CETis 69 for all the facilities provided for the implementation of the study and data collection. No financial support was received from any institution, university or company.

Abbreviations

CETis	Centre for Industrial and Service Technology Studies
<i>d</i>	Cohen's <i>d</i> (effect size)
SD	Standard deviation
EP-SG	Bridges to STEAM with a Gender Perspective Scale
M	Mean
<i>n</i>	Sample size
<i>p</i>	p-value
QUAL	Qualitative component (mixed design)
quan	Quantitative component (mixed design)
SPSS	Statistical Package for the Social Sciences (IBM SPSS Statistics)
STEAM	Science, Technology, Engineering, Arts, and Mathematics
<i>t</i>	t-statistic (Student's t-test)

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Analysis of higher education teachers' messages in a virtual forum about learning models

Análisis de los mensajes de docentes de educación superior en un foro virtual, sobre Modelos de aprendizaje

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Classification:

Area: Humanities and Behavioral Sciences

Field: Pedagogy

Discipline: Other pedagogical specialities

Subdiscipline: Other (Educational Technology)

 <https://doi.org/10.35429/JUM.2025.9.20.6.1.9>

History of the article:

Received: September 19, 2025

Accepted: December 10, 2025

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Abstract

This paper presents an analysis of messages posted in a self-directed online course aimed at teachers at a public university. The objective was to analyze messages from higher education teachers in a virtual forum about learning models. A mixed approach was used, and the method applied was the sequential exploratory method proposed by Creswell & Creswell (2023). In the qualitative part, content analysis with a category system was used, and in the quantitative part, descriptive statistics were used. The instruments were frequency concentration tables, and 79 teachers participated, generating a total of 125 messages. The platform instructions asked participants to comment on the topic and respond to another participant's comment. The contribution is as follows: methodologically, a way to analyze messages in online discussion forums and content; the importance of instructional design in online courses to achieve interactions with analytical or propositional content.

Resumen

Se presenta el análisis de los mensajes publicados en un curso autogestivo en línea, dirigido a docentes de una universidad pública. El objetivo fue analizar los mensajes de docentes de educación superior en un foro virtual, sobre Modelos de aprendizaje. Se trabajó un enfoque mixto, en la parte cualitativa se utilizó el análisis de contenido con un sistema de categorías y en la cuantitativa estadística descriptiva. Los instrumentos fueron cuadros concentradores de frecuencias, participaron 79 docentes que generaron un total de 125 mensajes. La consigna en plataforma solicitaba comentar sobre el tema y responder al comentario de otro participante. Como aportación se tiene: metodológicamente una forma de analizar los mensajes en los foros de discusión en línea; de contenido, la importancia del diseño instruccional en cursos en línea para lograr interacciones con contenido analítico o propositivo.

Analysis of messages from higher education teacher's. In a virtual forum on Learning Models

Goal

Methodology

Results

Analyzing messages in discussion forums



Locating messages
Encoding Analysis



Pay attention to following instructions. Dialogue is not generated. Experiences are not shared.



Messages + Coding = Interaction Type, Type of messages

Contribution: One way to analyze messages in online discussion forums.

Teacher Participation, Virtual Environments, Higher Education

Análisis de los mensajes de docentes de educación superior en un foro virtual, sobre Modelos de aprendizaje.

Objetivo

Metodología

Resultados

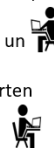
Analizar mensajes en foros de discusión



Ubicar mensajes
Codificación
Análisis



Atención en cumplir la consigna. No se genera un diálogo. No se comparten experiencias



Mensajes + Codificación = Tipo de Interacción, Tipo de mensajes

Contribución: Una forma de analizar mensajes en foros de discusión en línea

Participación docente, Entornos virtuales, Educación superior

Area: Promotion of frontier research and basic science in all fields of knowledge

Citation: Alatorre-Rojo, Elba Patricia, Pacheco-Cortés, Adriana Margarita and Galindo-González, Leticia. [2025]. Analysis of higher education teachers' messages in a virtual forum about learning models. Journal University Management. 9 [20]1-9: e6920109.



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Introduction

In recent years, virtual learning environments have been widely accepted as key spaces for teacher training and professional development, especially in higher education institutions, since, according to [Reyes-Angona et al. \(2023\)](#), ‘offer a flexible solution to teachers’ busy schedules, facilitate locally unavailable knowledge, structure their training path, and provide environments for asynchronous communication between colleagues’ (p. 12). For their part, [Pérez et al. \(2025\)](#), mention that ‘digital devices have changed the way access to information is perceived, especially in the field of education, which has generated great interest as a subject of study in the last decade’ (p. 3).

The expansion of online modalities has driven the use of new forms of pedagogical support, strategies that promote active participation, collaboration, and critical reflection among participants, as well as achieving experiential learning experiences that can be extrapolated to classrooms with students. According to [Eusebio \(2023\)](#), this educational modality ‘offers an educational opportunity to those who missed out on it at the time, have more problems accessing more rigid school schedules, or are located in geographical areas far from the centres or institutions where it is taught’ (p. 36). According to [Rojas, et al. \(2014\)](#), ‘Virtual training platforms, if good practices are implemented, increase students’ motivation to participate in activities’ (p.239).

For their part, [Alcivar et al. \(2022\)](#) refer to learning activities in virtual environments as enriching experiences that, in addition to providing information, promote the training of active students who construct their learning by taking advantage of interactions with others. However, the transition from traditional models to more participatory approaches in virtual environments is not automatic; it is necessary to understand how teachers interact in these spaces, what kind of discourse they construct, and how deeply they engage with the proposed content.

Learning management platforms allow the creation of virtual classrooms and offer opportunities to observe these dynamics through the messages that participants post in forums or comment sections, as it is in this space where the social construction of knowledge takes place.

The interaction and dialogue achieved through the messages that are posted reflect the collective processes of learning generation.

Currently, given the recognition of the benefits of pedagogical resources designed in virtual learning platforms, studying the posts made by participants and the interaction achieved despite the limitations of distance and time generates reflections on educational practice and course design in virtual environments. This document proposes a way of studying the messages posted in forums based on previously designed categories and the type of interaction that takes place in the development of a self-managed course in virtual environments, providing evidence of the elements necessary in instructional design to achieve efficient communication among participants, as well as the achievement of the objectives set.

The article is structured around the context in which the study was conducted; the problem being investigated, the objective to be achieved and a brief theoretical basis; the methodology, the results and their analysis.

Context

The study presented here was developed in the context of a continuing education course offered in a virtual learning environment by a public university to its teaching staff, with the aim of raising awareness among its academics of the importance of knowing and using technologies to develop new teaching models and introduce concepts related to active and adaptive learning.

The course lasted six weeks, was self-directed, was offered openly, and different groups were organised according to the affiliation of the applicants in the different centres of the university.

The course design included four major themes marked as chapters: (1) Most common learning models today, (2) Evolution of traditional teaching models, (3) Adaptive learning, (4) Innovative models. It was offered on Google Classroom, a platform that facilitates online learning management and, according to [Herrera et al. \(2025\)](#), ‘is a learning management system (LMS) that allows you to create virtual classrooms, share materials, assess learning, and establish asynchronous and synchronous communication between teachers and students’ (p. 2).

The methodology required participation in presentations via ZOOM by the course leader; review of reading materials and videos as a basis for answering reflection questions, the answers to which were recorded on the platform; and two final products.

The platform also had a Comments section (discussion forum) for each topic, with the instruction: 'Please comment on this chapter and respond to a comment from another person.' This section facilitated asynchronous interaction between participants, which supported learning and the social construction of knowledge.

The course under study had an introductory focus and centred on active and adaptive learning in different educational settings (online, hybrid, and without technology). The first chapter, entitled 'Most common learning models today,' covered the following topics: 1) Traditional face-to-face education model. 2) The Elite University Model. 3) Distance education model. and 4) Hybrid teaching models.

Problem

When working with self-directed online courses, the instructional design must support learning and participant interaction, since there is no advisor to provide feedback on comments and contributions, and the participant assumes this role.

If the instructions provided by the instructional design are not clear, comments are made in the forums, but not always reflections, discussions or exchanges of experiences. As a result of the above, it is interesting to study what interaction and what type of messages are posted based on a very general instruction in the virtual discussion forum of a self-directed course, on the topic of Learning Models, which is being worked on by university teachers.

The objective

Based on previously defined categories and taking into account only the first chapter of a self-directed course, the following objective is proposed: To analyse the messages of higher education teachers posted in a virtual forum on Learning Models.

Theoretical basis

Online discussion forums. - A tool that should be given importance in the platforms used to administer online courses are the so-called discussion forums, located in some platforms as a space for comments. According to [Reyes-Angona et al. \(2023\)](#), 'discussion forums need a pedagogical design that promotes the social construction of learning' (p.13). [Eusebio \(2023\)](#) states that these tools 'foster scenarios of asynchronous interaction, so that users can leave their messages at any time to be read at a different time' (p. 37).

Depending on the function assigned to the forum in the design, there are different types, including presentation forums, socialisation forums and forums that serve as a true space for learning construction, since, according to the advisor's instructions, participants delve deeper, analyse, make judgements or confront their peers' ideas until they arrive at products such as conclusions, outlines or summaries of the topics under study. 'The communicational quality of the platform is evident if it allows both asynchronous and synchronous interaction in two areas: teacher and student and among students.' ([Eusebio. 2023, p.37](#))

[Martínez, et al., \(2024\)](#), state that 'The purpose of discussion forums is to stimulate debate without exhausting the content being discussed' (p.165). In these written conversations, participants post and comment on messages, creating discussion threads. 'Discussion forums symbolise the virtual exchange of ideas, opinions and information, in which participants can express their agreement or disagreement with regard to a particular topic' (p. 166).

Interaction in virtual learning environments

Interaction in so-called online forums has evolved towards more complex forms of social knowledge construction. According to [García-Vargas et al. \(2022\)](#), asynchronous discussion allows for more reflective learning, so it is not just about information exchange, but also becomes a space for the development of metacognitive skills. For their part, [López et al. \(2022\)](#) state that 'facilitating the search and selection of information in forums and offering notices or recommendations on publications of interest could help to interact more frequently' (p. 75).

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<https://doi.org/10.35429/JUM.2025.9.20.6.1.9>

Muñoz-Basols and Fuentes (2024), citing Moore (1989,1), suggest that interaction ‘consists of three main types: 1) learner ↔ teacher, 2) learner ↔ learner, and 3) learner → content or materials’ (p. 188). These authors point out that interaction can be conditioned by factors such as: the teaching context, the environment or medium, the subject matter, the curriculum design, and the cultural component. (p.189)

When discussing interactions in virtual environments, it is important to pay attention to the content of the exchanges, which must address the teacher's presence, both cognitive and social.

Palomino and Ramírez (2010), citing Garrison et al. (200), define cognitive presence as ‘the degree to which participants are able to construct meaning from sustained communication’ and mention that teaching presence ‘includes educational design and the facilitation of learning processes, in which the teacher contributes their expertise on the subject and facilitates active learning’ (p. 81). For his part, Jerónimo (2009), cited by Palomino and Ramírez (2010), ‘defines social presence as the ability of beginners to project themselves socially and emotionally into a community of inquiry’ (p. 81).

Methodology

The course participants were a group of 134 teachers from a public university in Mexico, from one of the institution's University Centres, teachers with experience and training in the field of face-to-face teaching. In chapter 1 of the course, out of a total of 134 participants, 79 participated, generating a total of 125 messages, with different schedules and rhythms. The content of the analysis presented will be the messages posted by these 79 teachers during the time allocated for the work of the first chapter of the course.

A mixed research approach was used. According to Creswell and Creswell (2023), with this type of approach, a complete understanding of a research problem is developed by combining quantitative and qualitative results, quantitative data is explained in more detail with qualitative results, and a comprehensive understanding is developed to analyse groups through the combination of qualitative and quantitative data.

The qualitative aspect involves the collection and analysis of messages, which identifies the indicators to be worked on, while the quantitative aspect involves coding and counting the appearance of these codes in the published messages.

The study was exploratory and descriptive in nature and was based on the analysis of the messages posted by participants in the first chapter of the course.

The sequential exploratory method proposed by Creswell and Creswell (2023) was applied. These authors stated that it consists of a three-phase design (see Fig. 1): in the first phase, qualitative data are collected and analysed; in the second phase, the characteristics of the analysed data are identified; and, based on the results of these data, quantitative data are collected and analysed.

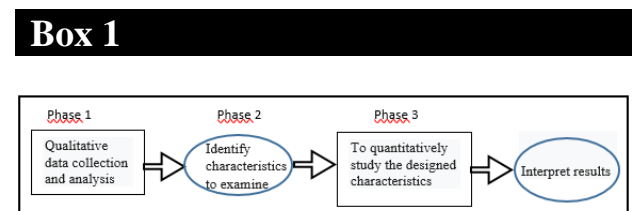


Figure 1

Explanatory sequential method

Source: Own Elaboration

To collect and analyse qualitative data, content analysis was used, a research technique that determines the frequency of indicators or keywords, uses coding, counting and interpretation, and interprets and quantifies textual data. A descriptive analysis using basic statistics was used to analyse the quantitative data. Content analysis can be manifest and latent; in the manifest analysis, statistics are sought, and the latent analysis allows for the categorisation of data patterns that provide material for the researcher to seek meaning in a specific context (Lázaro, 2021). In the study presented here, both types were applied, as there are percentages and explanations that allowed for the coding of the participants' intentions and not just their words.

A system of categories was designed for the analysis of the messages. This included the construction of indicators, operational definitions, and codes, which allowed the messages to be classified according to their content and level of interaction (see Table 1).

These indicators were constructed based on the reading of the published comments. Not all course participants posted messages, and some of these contain two or more of the indicators being studied.

Box 2

Table 1

Indicators, definition and codes for análisis

Indicator	Operational definition	Code
Interaction with others	They agree, add to ideas, comment on others' messages, greet others, and direct messages.	IC
General overview of the content	They mention something about the topic addressed.	GC
Position on models	They take a stance, either accepting or rejecting the models.	PM
Reflections on models	They raise challenges, requirements, and successes of the models being reviewed.	RM
Share your practice	They discuss their practice and experience.	CP

Source: Own Elaboration

Results

As already mentioned, the messages posted in the comments section of Chapter 1) "Most common learning models today" of an introductory course that encouraged reflection and dialogue were analysed. The instruction on the board was: "Please comment on this chapter and reply to someone else's comment." The 79 teachers who participated in this chapter, as already mentioned, generated 125 messages.

Of the 79 participating teachers, 53 responded to the prompt on the platform by posting ideas about what was reviewed in the chapter (RC), and 26 did not (No RC); 38 received and sent messages (RyE), 11 responded to the prompt but did not send messages to their peers (R No E), and 26 sent messages but did not respond to the prompt (E No R) (see Figure 2).

Box 3

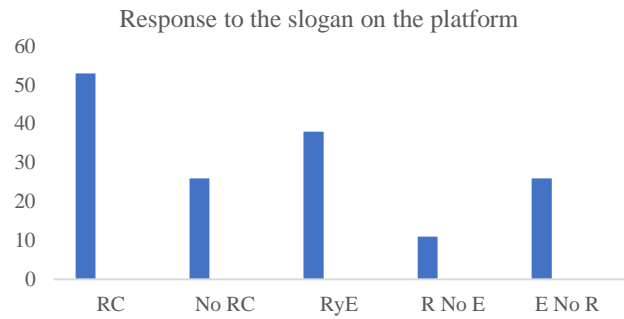


Figure 2

Participation of teachers responding to the prompt and sending messages to classmates

Regarding the messages posted: 64 of the participants send messages to a classmate, 38 comment on another classmate's message, 31 send and comment on messages, 23 of the messages sent are addressed to someone in particular, giving a social presence to the classmate to whom the message is addressed, 3 are addressed to EVERYONE, no participant signs their message, which indicates that the sender of the message does not show a social presence in the interaction (see Figure 3).

Box 4

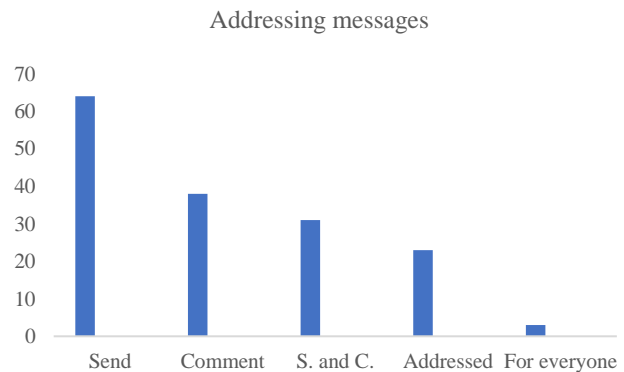


Figure 3

Sending messages

The messages were coded according to established codes. It should be noted that the published messages could present several indicators. Analysing the published messages and considering the general distribution of participation, it was found that in the first chapter of the course, there were interactions in 73 messages, taking this interaction to mean commenting on another, agreeing, comparing or giving a point of view on what was published, which is the highest indicator.

In 21 messages, phrases were found about the general content of the course, mentioning topics covered, which suggests that few paid attention to the general ideas of the content. In 39 messages, ideas were found that reflect the position taken on the models reviewed, showing that almost half of the participating teachers expressed a critical or accepting position on these models. In 34 messages, reflections on these models were made, showing a deeper level of thinking, and in 18 messages, participants' teaching experiences were published, showing that some participants linked their learning to their teaching experience.

Table 2 shows the frequency of indicators obtained in the messages posted in the first chapter of the course.

Box 5

Table 2

Frequency of indicators

Indicator	Code	Frequency of indicators
Interaction with others	IC	73
General content overview	GC	21
Approach to models	PM	39
Reflections on models	RM	34
Sharing your practice	CP	18
Indicator	Code	Frequency of indicators
Interaction with others	IC	73
General content overview	GC	21
Approach to models	PM	39
Reflections on models	RM	34
Sharing your practice	CP	18

Source: Own Elaboration

Analysis and discussion

The study, conducted in the context of a self-directed online teacher training course, focused on the interaction achieved by its participants and the type of messages they posted in Chapter 1 of the course. It is accepted that new technologies enhance virtual learning environments through access to information, interaction between participants, and the learning that is achieved. The literature suggests that self-directed learning prioritises interaction between students and content.

In the study presented here, the instructions given for the work in the comments section were: 'Please comment on this chapter and reply to another person's comment.' In response to this instruction, only 67% posted a comment on the chapter, Of these, 38% not only posted a comment about the course but also sent a message to one of their classmates.

According to Martínez et al. (2024), the purpose of discussion forums is to stimulate debate. Although there is interaction in the course under study, it is minimal, as most comments are directed at a single participant without starting a chain of comments or a discussion thread. Interaction is only found in more than one message in the thread of 20 conversations. This low participation can be attributed to the generality of the assignment, which did not include clear guidelines to guide the discussion. This may have influenced the lack of depth in the topics addressed, as commenting on a classmate fulfilled the assignment, which was a limitation in the instructional design.

With regard to the indicators detected, according to the depth of the interventions, Interaction with others (IC) and Generalities of content (GC) address the most basic aspects. Twenty-one phrases on generalities of content were found, reflecting that some messages reproduced general ideas that caught the attention of the participating teachers. Of the messages sent, 38 of them interacted with a colleague by commenting on their message, agreeing with or reinforcing the idea posted with phrases such as '...I agree with you that the hybrid model can provide interesting tools for our students,' '...you are absolutely right, the circumstances of this new stage led us to start giving these blended classes...,' 'As you rightly say, Dr., digital skills were not the main reason for not continuing the course online.'

Although 64 teachers sent messages, not all of them received comments from other colleagues to continue the discussion chain. For example, messages such as 'What activities would you like to include in the virtual context that you have not done in a face-to-face environment?' or 'Returning to your comment, Professor... what is your suggestion regarding how to be a mentor, guide, and motivator and not repeat your class every semester?' were posted and did not receive responses; there was no interaction, and no chain was continued.

In 39 messages, ideas were posted that reflect a generally accepting stance towards the media. Participants posted ideas such as: 'Without a doubt, taking advantage of the best of each model allows us to train professionals with problem-solving skills for their professional work,' 'the traditional face-to-face model is obsolete and we should be moving towards a hybrid model that takes advantage of the benefits of face-to-face and online work,' "Problem-based learning can be part of this new dynamic, not only for students but also for tutors,' 'Personally, I find the flipped classroom model very interesting and believe that its implementation in the learning units I teach could be quite beneficial,' and 'The traditional face-to-face model is obsolete and we should be moving towards a hybrid model that takes advantage of both face-to-face and online work."

These messages show that the teachers participating in the course accept as positive the new models that incorporate media and offer new possibilities for teaching.

Thirty-four messages were found with indicators of reflections on the media studied, with phrases such as 'the main problem is not the use of technology but a pedagogical problem, since it is not the same to be the guru who imposes their knowledge as it is to give students a certain amount of freedom to investigate and reason for themselves so that they can solve problems on their own,' "This chapter makes us reflect on the evolution of learning.

A traditional model that has worked for many years now faces a digitalised world and students familiar with the use of electronic devices and digital platforms, 'I began to reflect on what to do, what to take up again, what to leave aside, which strategies are really working as initially planned? I have thought about which activities are worth restructuring, which tools to incorporate, among other aspects. We are just getting started, and I truly believe that we have a great challenge ahead of us."

Participants focused more on fulfilling the assignment than on generating in-depth dialogue or sharing experiences from their teaching practice, as evidenced by the low number of messages about teaching practice (18) compared to those about interaction with others (73).

Messages about their practice included: 'In my personal experience in some of the learning units I am responsible for, I have applied this hybrid method, and I have encountered some problems with students who are not used to this method,' 'This semester, we have encountered students with difficulties connecting to the internet, with computers shared with siblings, which slows down their process,' 'I have found that when giving timely and almost instantaneous feedback to students when they are working from home, it is complicated, especially because each student works at their own pace and last-minute questions usually arise.'

Conclusions

The research aimed to identify the type of interaction and messages posted by trainee teachers in a virtual forum. Considering that only the messages from the first of the four chapters of the course were analysed, it is not possible to make generalisations, only contributions based on the findings.

When analysing the messages posted in the first chapter of the course under study, it is noted that the instructions were very general and no clear guidelines for participation were given, which may explain the lack of ideas about the models reviewed, whether in terms of characteristics, stance or challenges to their implementation. This can be attributed to the ambiguity of the instructions and the lack of clear guidelines for participation. This finding is consistent with the views of [Reyes-Angona, et al. \(2023\)](#), who state that 'discussion forums need a pedagogical design that promotes the social construction of learning.' In this case, the instructions, being so general, did not fulfil that purpose.

When it comes to education in virtual environments, discussion forums are an important communication tool, in this case the space for comments, since being asynchronous allows participants to socially construct knowledge among peers through reflection and analysis of what is being posted, respecting the times for posting.

The inclusion of indicators on positions and reflections suggests that it was a forum that presented levels of analytical and critical thinking that could have been exploited further if the discussion in the forums had been achieved by setting up discussion chains triggered by these contributions. According to García-Vargas et al. (2022), asynchronous discussion allows for more reflective learning; however, in the study conducted, the lack of clear guidance seems to have prevented that reflection from fully developing.

On the other hand, finding few statements about the participants' teaching practice can be interpreted as a weakness, either because the participants did not feel that the forum was an appropriate space to narrate their experience or because the instructions did not encourage them to do so.

Future research will analyse the type of interactions and messages that are achieved when the course in virtual learning environments is pre-designed and supported and accompanied by an advisor.

Conflict of interest

The authors declare that they have 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.

Contribution of the authors

Alatorre Rojo Elba Patricia: Her contribution was the idea for the project, the development of the method, the coding, the analysis and discussion of results, as well as the final drafting of the document.

Pacheco Cortés Adriana Margarita: She contributed to the method, coding, and literature review.

Galindo González Leticia: She contributed to the coding, literature review, and final draft review.

Funding

The research did not receive any funding.

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University internationalization in Mexico: Comparative analysis between physical and virtual student mobility through COIL strategies and mirror classes at a public university

Internacionalización universitaria en México: Análisis comparativo entre la movilidad estudiantil física y la virtual mediante estrategias COIL y clases espejo en una universidad pública

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Classification:

Area: Social Sciences

Field: Education Sciences

Discipline: Education

Subdiscipline: Comparative education

<https://doi.org/10.35429/JUM.2025.9.20.7.1.8>

History of the article:

Received: September 19, 2025

Accepted: December 10, 2025

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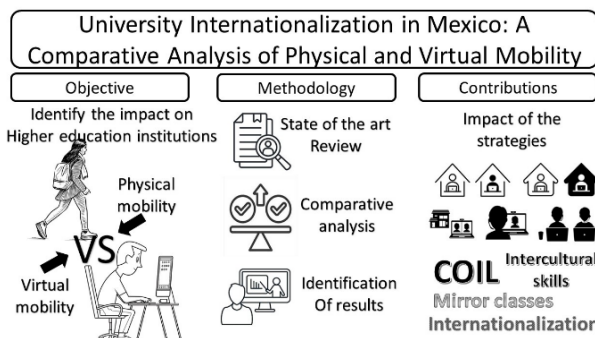


Abstract

This study analyzes university internationalization in Mexico by comparing in-person student mobility with the virtual strategies of COIL (Collaborative Online International Learning) and mirrored classes implemented at a public university. Through a theoretical and documentary review, their foundations, characteristics, areas of application, and educational outcomes are examined. The findings demonstrate that virtual strategies broaden access to international experiences by eliminating economic and geographical barriers, strengthening intercultural, digital, and communicative competencies. Institutional data show that student participation in virtual mobility far exceeds that of in-person mobility, confirming its growing relevance as a means of inclusive internationalization. Challenges related to academic coordination, technological capabilities, and faculty development are also identified. The study concludes that mirrored classes and COIL courses constitute innovative and sustainable tools for curriculum internationalization and academic cooperation in Latin America.

Resumen

Este estudio analiza la internacionalización universitaria en México mediante la comparación entre la movilidad estudiantil física y las estrategias virtuales COIL y clases espejo aplicadas en una universidad pública. A través de una revisión teórica y documental, se examinan sus fundamentos, características, ámbitos de aplicación y resultados educativos. Los hallazgos evidencian que las estrategias virtuales amplían el acceso a experiencias internacionales al eliminar barreras económicas y geográficas, fortaleciendo competencias interculturales, digitales y comunicativas. Los datos institucionales muestran que la participación estudiantil en movilidad virtual supera ampliamente a la movilidad presencial, confirmando su creciente relevancia como vía de internacionalización inclusiva. Asimismo, se identifican retos relacionados con la coordinación académica, las capacidades tecnológicas y la formación docente. Se concluye que las clases espejo y los cursos COIL constituyen herramientas innovadoras y sostenibles para la internacionalización del currículo y la cooperación académica en América Latina.

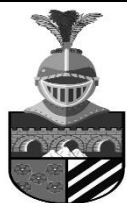


Internationalization of Higher Education, Virtual Mobility, COIL (Collaborative Online International Learning)

Internacionalización de la educación superior, Movilidad virtual, COIL (Collaborative Online International Learning)

Area: Development of strategic leading-edge technologies and open innovation for social transformation

Citation: Alcocer-Martínez, Fidel Ramón, Quijano-García, Román Alberto, Guillermo-Chuc, Giselle and Bernés-Salazar, Jimena. [2025]. University internationalization in Mexico: Comparative analysis between physical and virtual student mobility through COIL strategies and mirror classes at a public university. Journal University Management. 9 [20]1-8: e7920108.



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Introduction

The internationalisation of higher education has become strategically important for universities, particularly in Latin America, due to the need to prepare students to function in global, multicultural and highly interconnected environments. In Mexico, this process has historically been driven by physical student mobility programmes that allow direct cultural immersion in foreign institutions [Soto-Hernández, 2021]. However, economic, geographical and logistical barriers have limited the participation of a significant proportion of students, leading to inequality in access to meaningful international experiences.

Against this backdrop, virtual forms of internationalisation have emerged as innovative, inclusive and sustainable alternatives, notably mirror classes and Collaborative Online International Learning (COIL) courses. Both strategies base their effectiveness on international academic interaction through digital technologies, allowing students and teachers to participate in intercultural experiences without the need for physical travel [Simón Bolívar University, n.d.; García-Meza and González, 2025]. The growing adoption of these modalities in Mexican public institutions suggests a structural change in university internationalisation policies.

The objective of this study is to comparatively analyse the characteristics, benefits, limitations and educational impact of physical student mobility and virtual mobility—particularly in COIL and mirror classes—within a Mexican public university. The added value of this research lies in highlighting how virtual internationalisation contributes to democratising access to global experiences, enhancing intercultural skills and strengthening international academic networks, aspects that were traditionally attributed exclusively to face-to-face mobility [Borger, 2022; Hackett et al., 2023]. The central problem addressed in this study is to determine which modality—physical or virtual—generates greater reach and impact within a public university context characterised by budgetary constraints and socioeconomic inequalities. It also seeks to identify the differential elements between the two strategies and evaluate the relevance of virtual modalities as institutional mechanisms for sustainable internationalisation.

State of the Art

The internationalisation of higher education has become particularly relevant in recent years, largely driven by technological advances and the need to connect diverse academic environments without relying exclusively on physical mobility. In this context, mirror classes emerge as an innovative pedagogical strategy that promotes academic cooperation and intercultural learning through the use of virtual platforms. This methodology is an effective tool for strengthening the internationalisation of the curriculum and expanding opportunities for academic interaction between students and teachers from different universities around the world [Simón Bolívar University, n.d.].

The approaches included in current strategies for the internationalisation of the curriculum focus on integrating intercultural, international and global dimensions into academic programmes, classified in the literature as: face-to-face and traditional strategies, and virtual strategies and technological innovations [Valenzuela, 2024].

As part of face-to-face and traditional strategies, academic mobility through international exchanges via partnerships with foreign institutions seeks to enrich the learning of students and academics with international experience [Soto-Hernández, 2021]. Higher education institutions (HEIs) integrate intercultural and linguistic skills in order to prepare students for a global labour market [IES CINOC, 2024]; on the other hand, HEIs promote international collaboration through shared academic programmes, offering double degree options and joint research projects.

The virtual strategies used by HEIs are mainly based on technological innovations, ranging from asynchronous activities in which students manage their own progress on shared platforms installed in foreign institutions, to massive open online courses, known as MOOCs (Massive Open Online Course) [García-Meza and González, 2025], which are perceived as an underutilised strategy, mainly due to a lack of continuity in their development within institutions, a lack of local repositories, little encouragement to update them, and perhaps less appeal to students because they do not offer interaction with real international students.

Another virtual strategy is mirror classes, which are defined as a university collaboration strategy based on synchronous or asynchronous connection between two or more groups of students and teachers from institutions in different countries, who teach equivalent or complementary subjects using Information and Communication Technologies (ICT). Their main objective is to enrich the teaching-learning process through the exchange of cultural, academic and professional perspectives, contributing to the formation of a global-local profile in both students and teachers [Simón Bolívar University, n.d.].

Mirror classes, in addition to responding to internationalisation objectives, are linked to the global trend towards the virtualisation of teaching, especially in areas such as business and administration, where an understanding of international contexts is essential for professional training. Through these practices, institutions are able to implement a globalised, flexible and inclusive education that fosters the development of intercultural, communicative and digital skills [Yangali et al., 2021].

Mirror classes are an academic resource that allows the development of a course, chapter or project to be shared synchronously or asynchronously with foreign universities through a common digital platform. They are based on the principles of collaborative learning and the internationalisation of the curriculum, bringing the experience of academic mobility closer to those who cannot participate in face-to-face exchanges [Universidad Privada del Este, 2023].

Likewise, Yangali et al. (2021) highlight that this methodology is based on the theory of collaborative learning proposed by Vygotsky, where knowledge is constructed through social interaction and joint work.

From this perspective, mirror classes promote active learning, autonomy, critical thinking, and the development of intercultural and digital skills, which strengthen professional training in higher education. These practices are also aligned with the COIL model, which aims to promote global learning and university cooperation through the use of shared digital environments [Hackett et al., 2023].

The most robust virtual internationalisation strategy used by HEIs is COIL courses, which promote learning experiences in an intercultural context through virtual platforms, based mainly on teamwork with students from different countries [García-Meza and González, 2025]. COIL courses are characterised by collaboration between teachers from different international institutions to design and coordinate joint academic activities. Students are organised into mixed international teams and participate in collaborative projects that combine synchronous and asynchronous activities, with an emphasis on the development of intercultural and global competencies through the intensive use of information and communication technologies (ICT) [COIL UNAM, 2024].

The possibility of achieving internationalisation without the barriers of physical mobility, such as economic or geographical limitations, facilitates access to global experiences, favouring the development of intercultural, linguistic, communicative and problem-solving skills; promoting pedagogical innovation and academic collaboration among teachers, creating international networks of learning and cooperation [University of Burgos, 2025].

COIL Courses and Mirror Classes

Among the most relevant characteristics of mirror classes is their ability to integrate technological resources that facilitate communication and cooperation between students from different contexts. They involve coordinated planning between teachers, the use of shared platforms, the definition of common themes, and the implementation of collaborative activities such as forums, debates, case studies, and joint research projects [Simón Bolívar University, n.d.].

The profile of the teacher in a mirror class requires a more active role as an intercultural mediator and technology manager. According to the Manual for Mirror Classes [Pedagogical University of El Salvador, 2022], the teacher must possess pedagogical skills to plan virtual sessions, the ability to coordinate with fellow teachers, and mastery of ICT tools that facilitate synchronous and asynchronous communication.

In addition, they must foster a collaborative, respectful and participatory environment in which students feel motivated to interact with international peers. In this sense, the role of the teacher transcends the simple transmission of knowledge, becoming a facilitator of global learning and an agent of internationalisation [Yangali et al., 2021].

For their part, students are characterised by their willingness to work collaboratively, their cultural openness and their autonomy in learning. According to published studies, students who participate in mirror classes develop digital, communicative, and intercultural skills by interacting with peers from other countries and disciplinary contexts.

They are expected to possess initiative, responsibility, and the ability to adapt to different methodologies and educational systems [Pedagogical University of El Salvador, 2022]. In general, the literature on mirror classes agrees that both teachers and students must adopt proactive, reflective and collaborative attitudes, as the success of this methodology depends on the joint commitment of all participants [Barbosa, 2022].

COIL courses use a combination of technological tools that enable synchronous and asynchronous academic work to create multicultural teams that perform joint tasks that require more planning than mirror classes; LMS platforms, videoconferencing systems, forums, wikis, or shared repositories are not the end goal of COIL courses, but rather represent the means for intercultural and academic interaction [State University of New York (SUNY), n.d.].

In this type of course, teachers jointly design the syllabus with common learning outcomes and joint learning and assessment activities [Hackett et al., 2023]; and the most commonly used strategies range from collaborative learning in multicultural teams, projects based on real problems contextualised to the participants, guided intercultural reflective activities to achieve transnational cultural immersion, and shared formative assessments, all designed to achieve the simultaneous development of disciplinary knowledge and intercultural competencies [Borger, 2022].

The roles and attitudes of teachers participating in COIL focus on: designing and facilitating the learning experience, assessment activities, mediating intercultural conflicts, and promoting equity among students from different institutions [University of Glasgow, 2024]. Mastery of the disciplinary content of the agreed learning objective is a prerequisite for teaching peers, which must be accompanied by pedagogical skills to design collaborative learning, digital literacy skills, and an interest in curricular and intercultural internationalisation [Hackett et al., 2023].

Digital skills, cultural openness and curiosity, and a proactive attitude to communication are desirable competencies and attitudes among students participating in COIL courses [Borger, 2022].

Areas of application and needs addressed

Mirror classes respond to the need for higher education institutions to strengthen the internationalisation of the curriculum, promote intercultural learning and develop global competencies in students. They are particularly useful in higher education and postgraduate programmes, where the exchange of specialised knowledge is essential. In the area of business, they allow for the comparison of economic, administrative and financial approaches across different cultural contexts, broadening students' understanding of global business phenomena [Universidad Privada del Este, 2023].

Implementation processes in universities indicate that these activities have spread to fields such as engineering, health, education, and economics [Pedagogical University of El Salvador, 2022]. In Latin America, 67% of participating universities report having implemented mirror classes between 2020 and 2023, mainly with institutions in Mexico, Colombia, and Argentina, demonstrating their growing relevance in university internationalisation processes [Barbosa, 2022]. They also contribute to the fulfilment of institutional objectives of internationalisation at home, by providing an international educational experience without the need for physical mobility, which democratises access to global experiences and promotes educational equity [UNAN-Managua, 2024].

COIL courses represent an institutional opportunity for the formal internationalisation of the curriculum without the logistical costs of physical mobility, while also allowing for the development of academic networks among participating faculty [State University of New York (SUNY), n.d.]. For students, these courses allow them to develop intercultural, transnational, and communication skills in global contexts, improving employability opportunities and international teamwork experience [Hackett et al., 2023].

Among the most notable benefits are the diversification of teaching strategies, the strengthening of digital and intercultural skills, and the creation of academic cooperation networks between universities. They also encourage collaborative work, the updating of curriculum content in line with global dynamics, and the development of global thinking in students [Simón Bolívar University, n.d.]. Mirror classes promote active, student-centred learning and validate the content taught through interaction between international peers. They also motivate students to participate in multicultural contexts and strengthen their professional identity through the exchange of knowledge [Novoa et al., 2022].

However, virtualisation has its limitations. These include difficulties in coordinating schedules between countries, connectivity issues, differences in academic calendars, and the need for teacher training in the use of ICT [Novoa et al., 2022]. There may also be challenges associated with language, cultural adaptation, and the equitable assessment of learning in diverse contexts. Some institutions that apply it report that 42% of teachers face technical difficulties in the first implementations, although 85% indicated that the experience improved with institutional feedback [Pedagogical University of El Salvador, 2022].

Virtual mobility in higher education

Mirror classes have been successfully implemented in various higher education institutions in Latin America. UNAN-Managua, for example, developed joint projects with universities in Mexico, Argentina, and Colombia, consolidating international teaching teams and benefiting hundreds of students through collaborative activities and shared research [UNAN-Managua, 2024].

In the field of engineering and business, the University of La Frontera (Chile) and the University of Rosario (Colombia) applied this strategy in specialised courses, demonstrating that joint work between universities in different countries boosts student motivation and expands opportunities for interdisciplinary learning [Novoa et al., 2022]. Similarly, Yangali et al. (2021) showed that mirror classes promote the development of research skills in undergraduate students by allowing them to compare methodologies, theoretical approaches and results between Latin American institutions. These types of experiences promote teaching innovation and pedagogical internationalisation as part of the educational process.

COIL courses have been applied in disciplines such as the humanities and languages, social sciences, business and management, engineering, health sciences, and pedagogy [Spieler, 2025]. Case studies demonstrate successful implementations in both theoretical subjects and practical modules, including those using laboratories [Vaquerizo, 2025].

Methodology

This study was developed using a descriptive and comparative approach, based on a documentary analysis and theoretical review of university internationalisation, mirror classes and COIL courses. Recent scientific sources, institutional manuals, implementation guides, and empirical evidence from case studies in Latin America were integrated [Yangali et al., 2021; Hackett et al., 2023; Pedagogical University of El Salvador, 2022].

In addition, a statistical analysis was carried out on institutional data from the Autonomous University of Campeche (UACAM), collected between 2020 and 2024. This data included the number of students participating in physical mobility—both national and international—and those who participated in virtual internationalisation experiences through mirror classes and COIL courses.

The comparison of these figures made it possible to evaluate the relative impact and scope of both modalities within the same institutional context.

The methodology used made it possible to consolidate a comprehensive analysis that combines theoretical evidence with concrete institutional results, providing a robust comparative perspective for the evaluation of both modalities of academic mobility.

Results

The results reveal substantial differences between physical mobility and virtual mobility in terms of access, student participation, costs, academic cooperation, and the development of global competencies. As shown in Table 1, although physical mobility offers a significant advantage in terms of direct cultural immersion, its scope is limited due to economic, logistical, and administrative factors [Soto-Hernández, 2021]. On the other hand, virtual COIL and mirror class strategies substantially increase student participation, democratise access to international experiences and strengthen digital and intercultural skills [Borger, 2022; Universidad Simón Bolívar, s.f.].

Box 1

Table 1

Physical mobility: advantages and disadvantages

Advantages	Disadvantages
Total cultural immersion	High economic cost
Face-to-face experience	Limited scope
Intensive language skills development	Geopolitical, economic and social barriers
Impact on student identity	Complex procedures

Source: Prepared internally

The impact of mirror classes and COIL courses can be seen in multiple dimensions. On a pedagogical level, they enable students to strengthen cross-cutting skills such as effective communication, critical thinking and problem solving in multicultural environments. On an institutional level, they support internationalisation policies and promote interdisciplinary work between faculties. Finally, on a personal level, they foster empathy and openness towards other cultures [Yangali et al., 2021].

Box 2

Table 1

Virtual mobility: COIL and Mirror Classes

Advantages	Disadvantages
Democratises access to international mobility	Less cultural immersion
Develops intercultural and digital competence	Technological dependence
Facilitates the creation of sustainable academic networks	Requires high coordination among teachers
Institutional scalability	Requires training in ICT

Source: Prepared internally

In general terms, mirror classes and COIL courses are teaching strategies that strengthen the internationalisation of the curriculum, as can be seen in Table 2. They promote inter-institutional cooperation and enhance active learning. Their implementation requires planning, teaching commitment and adequate technological infrastructure, but their benefits in university education are widely recognised [Universidad Privada del Este, 2023]. On the institutional side, time and technological resources must be allocated for their operation, as well as recognition of activities that contribute to the internationalisation of higher education [State University of New York (SUNY), n.d.].

In the case of UACAM, data show that between 2020 and 2024, only 32 students participated in physical international mobility, while 503 students participated in virtual mobility through COIL courses and mirror classes. This represents a 1600% increase in student participation compared to traditional physical mobility. In proportional terms, only 0.4% of enrolment participated in physical mobility, while virtual mobility reached 6.8% of the total number of university students.

Conclusions

The results indicate that virtual mobility, especially through COIL strategies and mirror classes, is a powerful and effective mechanism for promoting internationalisation in Mexican public universities. Although physical mobility provides a deeper intercultural experience, its limited scope means that only a small number of students can benefit from it [Novoa et al., 2022].

In contrast, virtual mobility is positioned as a sustainable, scalable and inclusive strategy that responds to the contemporary challenges of higher education. It offers opportunities for mass participation, develops digital and intercultural skills that are highly valued in the global labour market, and strengthens inter-institutional academic cooperation through international learning networks [Hackett et al., 2023; Borger, 2022]. Furthermore, it contributes to the objectives of internationalisation at home, enabling global education without the need for physical travel [UNAN-Managua, 2024].

In conclusion, COIL and mirror class strategies should be considered fundamental pillars in the internationalisation policy of public universities. Their implementation not only complements physical mobility, but surpasses it in terms of scope and equity, becoming a strategic tool for educational transformation and the consolidation of a truly global university education.

Recommendations

Although virtual mobility strategies are less costly than physical mobility, it is necessary to allocate resources for the intensive training of teachers, students and institutional management areas. At the same time, the promotion of their implementation must begin with the teaching staff, providing them with the time and space to establish links with peers from institutions in other countries in order to develop an adequate strategy plan.

Declarations

Conflict of interest

The authors declare that they have 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.

Contribution of the authors

Alcocer-Martínez, Fidel Ramón: Contributed to the idea of the project, the research method, data analysis, discussion and conclusions.

Quijano-García, Román Alberto: Contributed to the research method, data analysis, discussion, and conclusions.

Guillermo-Chuc, Giselle: Contributed to the research method, data analysis, discussion, and conclusions.

Bernés-Salazar, Jimena: Contributed to the review of the state of the art, the research method, and data analysis.

Availability of data and materials

The spreadsheets used for data collection, comparative tables, and analysis are available upon request to the corresponding author.

Funding

The research was funded by the authors themselves.

Abbreviations

COIL	Collaborative Online International Learning
IES	Instituciones de Educación Superior
MOOC	Massive Open Online Course
SUNY	State University of New York
TIC	Information and Communication Technologies
UACAM	Autonomous University of Campeche
UNAM	National Autonomous University of Mexico
UNAN	National University of Nicaragua

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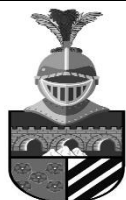
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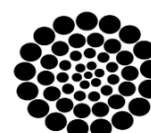
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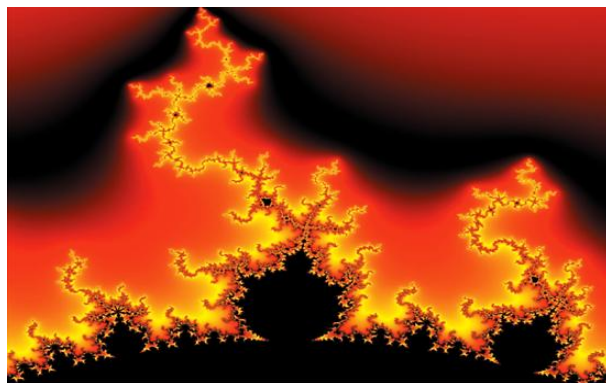


Figure 1

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Conclusions

Clearly explain the results and possibilities of improvement.

Annexes

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Declarations

Conflict of interest

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Abbreviations

List abbreviations in alphabetical order.

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ANN Artificial Neural Network

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