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Journal Practical Didactics

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Presentation of Content

In the first article we present, *Project-based teaching strategy for university students* by Ahumada-Maldonado, Blanca Irene, Ogaz-Vasquez, Alba Jyassu and Valles-López, César Iván, with adscription in the TecNM-Jiménez, as the following article we present, *Use of active methodologies and simulators in technical education* by Estrada-Castillo, Francisco Javier, Castillo-Flores, Esther Saraí, Fernández-García, Luis Guillermo and Esteve-Hollinger, Blanca Rosa, with adscription in the Universidad Tecnológica del Sur del Estado México, Universidad Tecnológica de Altamira and Universidad Autónoma de Tamaulipas, as the following article we present, *Metacognitive abilities and the development of mathematical thinking* by Sánchez-López, Guillermina, Salgado-Suárez, Gladys Denisse, Conde-Sánchez, José Rubén and Moreno-Aguilar, Ma. Antonia, with adscription in the Benemérita Universidad Autónoma de Puebla, as the last article we present, *Impact of the dual training model on graduates of technological degrees: Case of The Technological University of the South of the State of Mexico [2019-2024]* by Hernández-Domínguez, María del Rosario & Astivia-Arellano, Félix, with adscription in the Universidad Tecnológica del Sur del Estado de México.

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Project-based teaching strategy for university students

Estrategia didáctica basada en proyectos para universitarios

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Abstract

This document presents a teaching strategy based on constructivism and project-based learning (PBL) applied to first-semester accounting students at TecNM-Jiménez. The proposal aims to develop critical thinking, professional skills, and collaborative work through the creation of an innovative product made with regional raw materials and its corresponding research protocol. The methodology used was qualitative and phenomenological. Students integrated knowledge from various subjects, solved real-world problems, and participated in an academic competition. The results show that PBL benefited students by enhancing their critical thinking and helping them generate ideas for creating businesses using products native to the region.

Resumen

El presente documento presenta una estrategia didáctica basada en el constructivismo y el aprendizaje basado en proyectos (ABP) aplicada a estudiantes de primer semestre de la carrera de Contador Público en el TecNM-Jiménez. La propuesta busca desarrollar pensamiento crítico, habilidades profesionales y trabajo colaborativo mediante la creación de un producto innovador elaborado con materias primas regionales y su correspondiente protocolo de investigación. La metodología aplicada fue cualitativa y fenomenológica. Los estudiantes integraron conocimientos de varias asignaturas, resolvieron problemas reales y participaron en un concurso académico. Los resultados muestran que el ABP favoreció a los estudiantes en cuanto a potencializa su pensamiento crítico, auxilió a generar ideas de creación de empresas elaboradas con productos propios de la región.

Project-based teaching strategy for university students		
Objetivos	Methodology	Contribution
constructivist approach project based learning socio-emotional and professional skills	Qualitative research encompasses phenomena, explores them in a natural environment and in relation to the context of the participants. It is descriptive, as it specifies the properties, profiles and characteristics of people and subjects them to analysis.	The teaching strategy implemented in the research fundamentals course was well received by the students. The course was conducted in a very dynamic manner, with results that generated academic knowledge and professional and everyday skills. In addition, they had the experience of creating a micro-enterprise, with a product made from local raw materials and strategies for its commercialisation.

Teaching strategy, project-based learning, constructivism

Estrategia didáctica basada en proyectos para universitarios.		
Objetivos	Metodología	Resultados
enfoque constructivista aprendizaje basado en proyectos habilidades socioemocionales y profesionales	La investigación cualitativa abarca los fenómenos, los explora en un entorno natural y en relación con el contexto de los participantes. Es descriptiva, ya que especifica las propiedades, perfiles y características de las personas y las somete a análisis.	La estrategia docente implementada en el curso de fundamentos de la investigación tuvo una excelente acogida entre los estudiantes. El curso se desarrolló de forma dinámica, con resultados que generaron conocimientos académicos y habilidades profesionales y cotidianas. Además, adquirieron la experiencia de crear una microempresa con un producto elaborado con materias primas locales y estrategias para su comercialización.

Estrategia didáctica, aprendizaje basado en proyectos, constructivismo.

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

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Introduction

Currently, productive and social changes are taking place around the world, and universities are reviewing their teaching practices in order to train professionals who can meet the demands and needs of the world [Barrera et al., 2022]. The way in which people acquire knowledge has also changed. Students learn differently than they did in the past decade, and one of the factors contributing to this change is the modernity of various social networks. As a result, teachers at all levels are faced with the challenge of preparing classes that captivate their students.

Therefore, designing teaching strategies is a daily activity for teachers. For those working at the higher education level, it is recommended that the activities they propose promote critical thinking.

Social needs contribute to changes in government priorities, such that the current 20-30 agenda sets out 17 objectives, which form the basis for education. It is therefore suggested that teaching strategies include projects for students so that they can propose solutions from their perspective. Education has undergone significant changes over time due to its fundamental role in the development and training of individuals and the progress of diverse societies. These rapid changes in the last century that society faces are: technological and scientific advances and globalisation [Ballesteros et al., 2018].

It is advisable for higher education teachers to design their teaching strategies in such a way that students activate their analytical skills, can link theory with practice, and enjoy the activities presented to them by the teacher. It is suggested that the work proposals developed or designed by higher education teachers as teaching strategies should be dynamic and interesting for the people who are going to carry them out, so that students feel that they are part of their environment and everyday problems, with the aim of learning to resolve the conflicts of today's society and building their learning in a participatory way. "Teaching strategies in education have a great effect on the development of student learning, with positive results that benefit both the teacher and the student [Herrera and Villafuerte, 2023, p.758].

In the same vein, "the teaching strategy developed by the teacher and the tasks and activities that comprise it should encourage students to build their knowledge and take responsibility for developing their skills and socially acceptable behaviours [Zambrano et al., 2022, p. 176].

1. Justification

In today's globalised world, education faces great challenges, with continuous and significant changes transforming contemporary society. In academia, teachers are advised to seek pedagogical methods or teaching strategies that strengthen the development of critical thinking in students, as this type of reasoning enables individuals to analyse, understand and evaluate the knowledge around them in a reflective manner, thus creating a personal interpretation of the world that helps them adapt and perform in the workplace [Ballesteros et al., 2018].

At the undergraduate level, teaching strategies can be prepared for students by linking several subjects with the intention of solving community problems through project-based learning. The final product may be the answer to solving the conflict raised by teachers. 'One of the focuses of the work carried out by higher education institutions is the search for teaching strategies that promote the development of skills that enable people to live a full life and function in society' [Barrera et al., 2022, p.278]. This can generate critical thinking in people and help them construct their own learning.

One definition of 'teaching strategies' is 'procedures planned by the teacher with the aim of facilitating student learning through the use of resources, activities and techniques that promote knowledge construction' [Díaz and Hernández, 2010, p. 140]. In the various subjects taught at HEIs, it is possible for teachers of two or more subjects to develop strategies with the aim of encouraging students to analyse theory and practice.

The subject constructs knowledge of reality, since reality cannot be known in itself, but only through the cognitive mechanisms available, mechanisms that, in turn, allow for transformations of that reality [Araya et al., 2007, p. 77].

2. Statement of the problem

In higher vocational education, one of the most significant challenges is to ensure that students acquire and develop comprehensive skills that enable them to apply theoretical knowledge and practical application in a critical, creative and collaborative manner in real-life scenarios. However, a large proportion of educational programmes still use traditional teaching methods that limit students' active participation and their ability to generate their own meaningful knowledge.

Even though educational plans and programmes promote student-centred learning, project-based learning and critical thinking, their application in the classroom has been limited. This restricts students' ability to deal with everyday situations that promote decision-making, problem-solving and self-assessment of their own learning.

The definition of learning is 'acquiring knowledge of something through study or experience involves interacting with the environment, experimenting, collaborating and reflecting.' From a constructivist perspective, 'learning means actively constructing knowledge; it is not simply receiving it passively from the environment or the teacher, but elaborating it and integrating it with prior knowledge' [Ausubel, 2002, p. 34]. Project-based learning provides the environment for this.

This strategy allows students to participate in meaningful activities that combine theory with practice and the attitudes necessary for training.

In this sense, a project-based teaching strategy was designed and implemented, based on constructivism and focused on the development of critical thinking, with the aim of positively impacting student training. The intention is to strengthen students' knowledge-building and collaborative work skills by involving them in real-world projects.

According to the syllabus for the research fundamentals course established by the higher education institution, it states that:

The course was designed to contribute to the comprehensive training of students...

It develops research skills that are used for conceptual, procedural, and attitudinal learning contained in the curricula of the educational programmes offered...

It should employ constructivist learning strategies that allow students to achieve skills in analysis and synthesis, strengthen oral and written communication with the support of ICTs, and enable them to identify scenarios for intervention in their professional field [Tecnológico Nacional de México, 2016].

With the aim of making the subject more dynamic and encouraging teamwork, a teaching strategy was designed based on project-based learning that would encourage critical thinking. As a final product, it requires an integrative disciplinary project that involves students in the knowledge of their career and is an important part of their assessment in this subject, which consisted of students developing an innovative product with commercial potential, using products or raw materials from the region and using this information to develop their research protocol.

3. Objectives and research questions

General objective: To design and implement a teaching strategy based on the constructivist approach and project-based learning to encourage the development of critical thinking and professional skills in higher education students.

Specific objectives:

To design and implement a project-based teaching strategy based on the constructivist approach.

Observe and describe the process of developing student projects for the active construction of knowledge.

Evaluate the professional and socio-emotional skills promoted through collaborative work and the resolution of real problems.

Research question:

How does a teaching strategy based on the constructivist approach and project-based learning influence the development of critical thinking and professional skills in higher education students?

4. Theoretical framework

Teachers design or adapt various activities, known as strategies, for their classes. To this end, 'a teaching strategy is a set of activities planned by the teacher with the aim of facilitating meaningful learning in students' [Díaz and Hernández, 2010, p. 135]. At the higher education level, the planning of assignments should pursue several objectives, including academic transversality and the establishment of solutions to real problems, in order to awaken the capacity for analysis and the theoretical-practical link.

The tasks assigned can be carried out through projects in which students can develop academic knowledge, research skills, social skills, investigative skills, communication skills, among others, in such a way that learning is meaningful and comprehensive.

Teaching strategies are physical and mental activities and functions that facilitate the student's encounter with the goal of knowledge and a relationship of help and cooperation with peers during learning in order to complete the task with the required quality [Ribadeneira, 2023, p. 788].

In the same vein, learning is an active and constructive process in which individuals acquire knowledge, skills, and strategies not only through direct experience but also through observation of others and interaction in social contexts [Bandura, 1986]. According to the above definition, active participation in the teaching strategy will generate learning for those involved. 'Project-based learning is a student-centred methodological strategy that promotes meaningful learning through the planning, development and evaluation of a project related to their reality' [Díaz Barriga, 2005, p. 86].

The application and solution of the project-based teaching strategy can help to enhance meaningful knowledge with real problem solving.

With work planned for students and based on project-based learning, they report that it is a teaching strategy that promotes the active participation of both students and teachers [Barrera et al., 2022, p.279].

When teachers develop academic assignments with various activities for students to carry out and guide them to complete what is requested, this is referred to as project-based learning.

This translates into a way of thinking based on rigorous standards of excellence and a conscious awareness of their application. Critical thinking is self-directed, self-disciplined, self-regulated and self-correcting judgement [Paul and Elder, 2014].

To carry out a student project, students must meet the characteristics described above. They will also develop skills in consultation, research, analysis, problem solving, coexistence, and proposing improvements if the project is in the social sphere. A teaching strategy based on constructivism was established: 'knowledge is not transmitted, it is constructed' [Piaget and Inhelder, 1970, p. 15].

5. Methodology

The research was carried out at TecNM-Jiménez between August and December 2024 with first-semester students studying to become public accountants. Qualitative research encompasses phenomena, explores them in a natural environment and in relation to the context of the participants.

It is descriptive, as it specifies the properties, profiles and characteristics of people and subjects them to analysis. It has a phenomenological approach, understanding the meaning that people experience and giving meaning to their experiences.

It also generates or adjusts research questions through interpretation with collected non-numerical data [Hernández et al., 2014].

The division of labour in the strategy consisted of the following steps: researching processes to develop a product, costing it and calculating its sale price, and finally preparing the research protocol report.

To carry out this work, they linked knowledge from a large number of subjects such as accounting, ethical management, costs, human development, social dynamics, among others.

With the aim of making the subject more dynamic and encouraging collaborative work, a teaching strategy based on constructivism and project-based learning was designed. This consisted of students developing an innovative product with raw materials from the region and marketing potential, and concluding with the preparation of a research protocol. As part of the process, students had to investigate the procedures necessary for the production process, calculate costs, and establish the selling price of their product.

To accomplish this task, they integrated knowledge acquired in various subjects, which allowed for an interdisciplinary and contextualised learning experience.

To comply with the project-based learning strategy, they formed teams of up to three members, designed an innovative product using raw materials from the region and marketed it, in addition to participating in a local academic competition called 'Rumbo a Expociencias 2024' [Towards Expociencias 2024]. To carry out the task, the work was divided into several stages: generating the idea, researching ingredients for the product, the manufacturing process, marketing, costs, setting the sale price, and developing a research protocol. To support the development of the project, a visit was organised to the Natural Resources Research Centre, where the students were provided with information about the production and processing of some of the products they made, such as banana jam with amaranth, matcha yoghurt, dehydrated fruits and vegetables, and walnut cream, among others.

They then strengthened their knowledge with further research and wrote journals on each attempt to make the products, with the aim of improving them each time they produced them. During the semester, they worked on production, marketing, costs, sales, and writing their research protocol.

The work has a phenomenological approach, understanding the meaning that people experience and give to their experiences; it is descriptive, as it specifies the properties, profiles, and characteristics of people and subjects them to analysis; it also generates or adjusts research questions through interpretation with non-numerical data collected, which is qualitative in nature [Hernández et al., 2011].

In the August-December 2024 semester, a teaching strategy was designed, based on project-based learning [PBL], with the aim of enhancing the critical thinking of first-semester students in the Public Accountant programme, as well as participation in the event leading up to Expociencias:

Developing technology-based and creative projects with scalability characteristics that encourage research and technological development capabilities in solving problems in the different public, social and private sectors at the local, regional and national levels, as well as strengthening innovation and entrepreneurship processes among participants [Tecnológico Nacional de México, 2025].

In the same vein, the objectives of Agenda 20-30, especially the fourth one on quality education, refer to 'by 2030, substantially increase the number of youth and adults who have relevant skills, especially technical and vocational skills, for employment, decent jobs and entrepreneurship' [United Nations, 2016, p.15].

Based on this proposal, a teaching strategy was designed based on the constructivist model 'knowledge is not copied from reality, but is actively constructed by the subject' [Piaget and Inhelder, 1973, p. 15] and project-based learning [PBL], as it is an active methodology that derives the importance of social interaction and relationships with other people in the development of human behaviour [Causil and Rodríguez, 2021].

The strategy was called 'Research Protocol towards Expociencias'.

The teaching strategy was applied in the August-December 2024 semester in the research fundamentals course, which has four units, the last part culminating in the submission of a research protocol.

The work process was as follows: Teams of a minimum of two and a maximum of five people were formed and asked to come up with a research idea for an innovative product made from raw materials from the region, which would then be marketed.

To carry out the task, they researched the procedure for making the chosen product. Once they had consulted the steps, each time they made the product, they wrote in a journal about the progress or setbacks in production. Some teams sold something. Once they had finished developing the production process and presenting it, the experimental stage was over, and they continued with writing the protocol.

Part of the team devoted themselves to writing the research protocol for the presentation. To give an example, the first unit covers topics such as the relationship between man, knowledge and reality and the process of constructing science. This information was provided to link knowledge with the requested project. The second unit studies the tools of oral and written communication, which was therefore essential for the preparation and presentation of their final project.

The third part of the syllabus is the study of the development of their profession and its current state, in such a way that researching how a product can be made with raw materials from the region and then marketed is part of the economic activity that forms the profile of accountants, as well as having an impact on the 20-30 agenda. To conclude the process, the last unit is to write up the research process.

During the semester, a visit was made to the Natural Resources Research Centre, where staff from the institution provided information on the process of making products with raw materials from the region. The researcher who attended to them has extensive experience in this field and also attended to the teams individually who had questions and advised them on the production process for some of their products, including matcha yoghurt, banana jam, walnut cream, and dehydrated vegetables, among others.

The students implemented the recommendations and made changes to their products that significantly improved them.

6. Results

A teaching strategy was designed for the research fundamentals course, called 'research protocol for Expociencias';

A project was requested to be carried out during the semester, and the final protocol submission had to include a cover page, table of contents, problem statement, research question, objectives, justification, scope, theoretical framework, hypothesis [if applicable], methodology [approach, type of research, design, participants, project stages, product selection, cost and investment analysis, production and inventory control, marketing, accounting records, preparation of financial statements, logs, accounting records]; ethical considerations; timeline; necessary resources; references; appendices.

The final product should be submitted before the academic event takes place and presented to the judges on the day of the competition.

In accordance with what was requested in the strategy, critical thinking was part of the dynamic, according to Prieto, 2006, as cited in [Causil and Rodríguez, 2021](#): the development of competencies in educational contexts involves identifying problems in the professional environment, becoming aware of one's own learning, planning learning strategies, as well as skills such as critical thinking, decision-making, self-directed learning, peer collaboration, evaluation and self-evaluation, conflict resolution, lifelong learning, and social skills [p. 23].

In addition, the student was the builder of their own knowledge by developing the entire strategy process. Eight teams presented very diverse proposals.

During the August-December 2024 school period, the reactions of the main actors were diverse, to mention a few: enthusiasm, investigative, denial, thinking that they would not achieve it, and the opposite, carrying out the idea and perfecting it each time. The team that made the banana jam sought advice from a nutritionist and a food chemical engineer to improve the product, and their perseverance and research work yielded favourable results, winning second place.

Similarly, the matcha yoghurt team bought milk from various producers until they found the one that best suited their product.

The dehydrated fruit and vegetable team's first attempts were unsuccessful; they could not find the right balance for the proper presentation of their snacks, and at one point they wanted to give up.

The teacher's job was to convince them to continue with trial and error until they were satisfied. It is worth mentioning that this was one of the winning teams.

Likewise, the students who made the walnut cream took less time to produce their product than the previous teams, but it was very successful and they managed to sell it during the semester. On the other hand, there were some students who made vegetable gummies such as carrots and beetroot. This team had difficulties integrating with each other, but despite this, they managed to make the gummies, submit the protocol and enter the competition. Two teams made plates and paper by recycling notebook pages.

Both teams said that at first they only did it to fulfil the requirements, but as the semester progressed, they became attracted to the idea, although they did not have much time left to do a better job. Finally, the team that made charcoal from walnut shell waste was the winning team. They undoubtedly invested time in improving their product and researching and refining the production process.

In this intervention, the students were able to actively build their knowledge, enhance their critical thinking, and project-based learning made the class more dynamic and brought together knowledge from various subjects they were already studying and others they had yet to study, so they had to consult others in order to submit their reports. However, this was not an obstacle for them to overcome.

Critical thinking was evident in the students from the moment they generated the idea and carried it out, in addition to completing the entire process of development, costing, marketing, and documenting, as well as improving each time they made and documented the product's production process, when they presented and defended their product in front of the jury. The professional skills they developed were analysis, reflection, planning, decision-making, problem-solving, financial statement preparation, oral and written communication, teamwork, and leadership.

Some team members developed some skills more than others, but by the end of the semester, they had undoubtedly grown as students, individuals, and future professionals. When the competition ended, everyone looked very satisfied and proud, even though only a few teams won.

Each team was able to solve problems and work on the project, generating ideas and seeking support not only from their teacher but also from other people trained in what they set out to do, such as nutritionists, food chemical engineers, and doctors of science.

Likewise, the judges' logs in the evaluations of each team showed the professional and socio-emotional skills developed through collaborative work and the resolution of real problems.

7. Conclusions

The project-based teaching strategy in this study helped students to enhance their critical thinking and generated ideas for creating micro-enterprises based on products from the region.

Furthermore, subjects that university students perceive as filler and boring can be presented in a way that challenges them to present solutions to problems or generate businesses that can help them in their way of life and help them attract the attention and collaborative work of students and generate professional and life skills in each participant, encouraging analysis and problem solving. In addition to the above, the students generated a business idea using raw materials from the region to transform and market them.

8. Contributions

The teaching strategy implemented in the research fundamentals course was well received by the students. The course was conducted in a very dynamic manner, with results that generated academic knowledge and professional and everyday skills.

In addition, they had the experience of creating a micro-enterprise, with a product made from local raw materials and strategies for its commercialisation. It is hoped that this can be implemented in the next semester.

Anexos

Box 1



Figure 1

Présentation finale des projets

Source : Propre

Declarations

Conflicts of interest

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

Contribution of authors

Ahumada-Maldonado, Blanca Irene: Contributed to the generation of the project idea and was a teacher in the research group in which the work was carried out.

Ogaz-Vasquez, Alba Jyassu: Collaborated in the search for information, conceptual and methodological development of the research, and analysis of the results obtained.

Valle-López, César Iván: Collaborated in the organisation of the closing event, the creation of the jury's logs, and the interpretation and analysis of the results obtained.

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Use of active methodologies and simulators in technical education

Uso de metodologías activas y simuladores en la educación técnica

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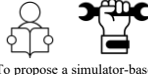
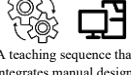
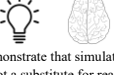
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Abstract




This investigation proposes a methodology based on virtual simulators for teaching CNC lathe and mill programming in technological high schools. Given the lack of physical equipment, a seven-stage process is suggested: paper design, algorithms, ISO coding, virtual machine setup, execution of the programs, digital pieces as result and feedback, all of this, integrating ICTs to minimize the gap between theory and industrial practice. Expected results include increased student creativity and precision, as well as adaptation to real-world work environments. Challenges are identified, such as students' low digital literacy and the need to adjust teaching pace. The whole strategy seeks to develop analytical and multidisciplinary skills.

Use of simulators in the practical part of education at the upper secondary level		
Objective	Methodology	Contribution
 <p>To propose a simulator-based methodology to strengthen practical programming instruction on numerical control (CNC) lathes in technological high schools, addressing physical resource limitations and gaps in students' digital skills.</p>	 <p>A teaching sequence that integrates manual design, algorithms, ISO coding, virtual simulation, and iterative feedback, linked to higher education institutions for real-life practice.</p>	 <p>To demonstrate that simulators, while not a substitute for real-life experience, enhance analytical understanding, creativity, and multidisciplinary, facilitating the transition to the workplace.</p>

CNC simulators, ICT in manufacturing, active methodology

Resumen

Esta investigación propone una metodología basada en simuladores virtuales para la enseñanza de la programación de tornos y fresadoras CNC en escuelas técnicas superiores. Dada la falta de equipo físico, se sugiere un proceso de siete etapas: diseño en papel, algoritmos, codificación ISO, configuración de la máquina virtual, ejecución de los programas, piezas digitales resultantes y retroalimentación. Todo ello, integrando las TIC para minimizar la brecha entre la teoría y la práctica industrial. Los resultados esperados incluyen una mayor creatividad y precisión en los estudiantes, así como su adaptación a entornos laborales reales. Se identifican desafíos, como el bajo conocimiento digital de los estudiantes y la necesidad de ajustar el ritmo de la enseñanza. La estrategia en su conjunto busca desarrollar habilidades analíticas y multidisciplinarias.

Uso de simuladores en la parte práctica de la educación a nivel medio superior		
Objetivo	Metodología	Contribución
 <p>Proponer una metodología basada en simuladores para fortalecer la enseñanza práctica de programación en tornos de control numérico (CNC) en bachilleratos tecnológicos, abordando las limitaciones de recursos físicos y las brechas en habilidades digitales de los estudiantes.</p>	 <p>Secuencia didáctica que integra diseño manual, algoritmos, codificación ISO, simulación virtual y retroalimentación iterativa</p>	 <p>Demostrar que los simuladores, aunque no sustituyen la experiencia real, mejoran la comprensión analítica, la creatividad y la multidisciplinariedad, facilitando la transición al ámbito laboral.</p>

Simuladores CNC, TIC en manufactura, metodología activa

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

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Introduction

Industry 4.0 [i4.0] is currently growing in the country, and educational programs are not as dynamic as they could be because, as Castillo [2023] mentions, there is a conflict of educational relevance in the face of sudden technological changes that are currently impacting industrial processes. These changes have become an all-encompassing phenomenon in which societies and future jobs are inevitably involved in one way or another, without realizing it, as is the case with artificial intelligence and the excessive use of the internet and automation, among other aspects.

Therefore, in upper secondary education in the area of vocational training, it becomes important to help students develop skills that are as compatible as possible with the almost immediate technological future that our industrial scenario increasingly presents.

The proposal will be developed at a DGETI educational institution, with the subjects of module 4 of the fifth semester, corresponding to the subjects entitled: 'Machining mechanical parts on a numerically controlled lathe' and 'Machining mechanical parts on a numerically controlled milling machine'.

Programming the machining sequence on a numerically controlled lathe

Prepare the machining sequence on the numerical control lathe

Machine parts on the numerical control lathe

Check the results obtained, expressing ideas and concepts through the programming sequence.

Relate symbolic expressions using information technologies through the CNC [Computerized Numerical Control] program developed.

Checking the results obtained, expressing ideas and concepts and considering current safety regulations by obtaining the mechanical parts machined on the CNC lathe.

The added value is the combination of various elements or educational models for technical training that allow us to develop the teaching-learning process in an optimal, agile, fluid and meaningful way for upper secondary school students.

The working method to be used will require the implementation of the traditional model of direct instruction together with the active methodology of the Flipped Classroom and the use of simulators [Virtual Learning, VL], which together aim to reduce the time spent on theory or independent work by the student to a minimum in order to focus on direct instruction through the review of material, simulation from preparing the virtual machine to executing a program, and the resulting feedback corrections.

Therefore, it will be necessary to use checklists to assess improved procedural understanding.

The existing problem is the perception of difficulty of the topics presented as subjects, due to both low technological literacy, mathematical deficiencies in workshop calculations and programming topics, under the premise that everything technological is complex and extremely difficult. In addition, the campus has a limited number of computer labs, but they are ultimately available for use, which allows students to work directly on developing ICT skills.

Therefore, the hypothesis to be tested is whether using a work methodology that balances the aspects identified as areas of opportunity and, based on them, builds small, sequential, meaningful processes for knowledge accumulation will allow students to perform acceptably in their graduate profile competencies in CNC equipment programming.

To begin with, we can affirm that simulators allow for risk-free experimentation, enabling students to understand the dynamics of complex processes [Rojas, 2003], and that ICT in technical education must be aligned with active approaches that promote student autonomy.

Based on classroom experiences, students show a high percentage of disinterest in ICT due to stigmas about industrial mechanics that identify it as 'dirty work' without the interference of technology.

Additionally, students have deficiencies in office automation and algorithmic thinking [e.g., flowchart design] and have very limited access to real CNC machines.

Castañeda [2003] proposes that for this research, we understand Information and Communication Technologies [ICT] to be those tools that, based on the use of computers, allow for the storage, processing, presentation, and transmission of digitized information.

Rodríguez et al. [2016] consider that the use of ICT by students is linked to the teacher's educational approach and, according to the educational uses to which they are put, classify ICT into three categories: a) ICT that support the transmission of messages from the sender to the recipient, b) ICT that supports active learning through experimentation with the objects of study, and c) ICT that facilitates interaction for learning.

Rojas [2003], for example, investigated the development of simulators based on cases and dynamic modelling for the maintenance of quality systems. Based on the analysis of the results of the exams administered to both the control group and the experimental group, it was concluded that there were significant differences in learning between the students who used the simulator and the students who were only taught using the traditional case method. The group using the simulator showed a greater understanding of the dynamics that gave rise to the problem in the case, which resulted in more complete and accurate answers in the assessment questionnaire.

In order to develop the activities relevant to the aforementioned module, which addresses the programming of numerically controlled lathes and milling machines, a sequence is required that allows us to identify the steps to follow to successfully complete a manufacturing programming process. Rather than simply assigning tasks to be performed, in the industrial mechanics module, we aim to convey the best practices that govern the manufacturing industry itself, in order to facilitate the student's short-term entry into the labor market, if necessary.

Part of the difficulty in addressing programming in the areas of industrial mechanics is the generic idea that it involves 'iron' and 'getting dirty with grease,' which has become stigmatized.

However, our job as teachers is to give a professional touch to secondary schools, referring to the glory days of past years, it therefore starts from an environment with low capacity for interaction with ICTs, as "they do not see any application for them if they are going to be industrial mechanics". This type of thinking has an impact on analytical performance when drawing up a flowchart or algorithm to outline the manufacturing idea required to solve a programming problem in numerical control, whether on a milling machine or a lathe.

The general context of the students is one of a certain deficiency in office automation, for which a work methodology is followed that allows them to be the designer and their own developer throughout the creative cycle, enabling them to 'materialize' their creation through links with higher education institutions that allow us to use CNC machinery and enable students to put what they have learned into practice in the laboratory, simulating a professional throughout the process.

It should be noted that the use of simulators is sometimes an alternative route to achieving the objectives of the subjects in the absence of equipment, which means that, despite the errors shown in simulated situations, it will never replace the real conditions of work performance. To reinforce this point, I would like to mention an experience I had during a visit to a higher education institution that allowed us to use its numerical control machinery.

When the students expected to simply arrive with their USB sticks, read the file and run it to receive the physical piece in their hands, they were faced with the everyday situation in which the numerical control machine must be adjusted for the process to be carried out, which took up two hours of their eagerly awaited visit to a numerically controlled machining area.

The methodology used and adapted, for example, to Module IV of CNC Mechanical Parts Machining, involves the following:

1. Design of the part with specific dimensions by drawing on graph paper. See Figure 4.
2. Design of an algorithm of activities to be carried out in order to have a guide when developing the programming.

3. Coding of the design into ISO CNC language, lathe or milling machine, as applicable.
4. Preparation of the CNC machinery [raw material, cutting tools, parameters, accessories] using the simulator.
5. Configuration of the zero point in the simulator.
6. Execution of the designed program [error detection and correction].
7. Virtual obtaining of the expected part.

This methodology can be rethought and is not limited to use in professional subjects only, but also in disciplinary subjects. In some subjects, such as physics, simulators are perfectly suited for conducting laboratory experiments in a virtual environment; experiments that in most cases are difficult to carry out in the real environment due to the scarcity of materials and additional resources.

The instrument used is a checklist to verify only that the student understands the process in its general context and is able to follow a procedure.

This methodology is used throughout the semester, across two sub-module subjects, with the aim of reinforcing the way of working and subsequently generating an appropriate rubric.

As a result of this methodology, the students performed better than they themselves expected, since, once their creativity was awakened, they came up with a flood of ideas for the 'n' ways to make a design. A sample of the work is shown in Figures 1 to 3, in the annexes section.

Strengths [what was done well]

Self-directed learning was developed, as well as decision-making regarding the approach to algorithms or flowcharts proposed to solve the manufacture of the piece, by confronting the student with the solution of problems in the manufacture of various pieces, giving them the leading role as programmer of the way in which it will be carried out.

The sense of analysis is reinforced by reviewing all the information relevant to the production of the parts, in addition to the considerations to be added in the real situation, through the verification of the relevant flowchart, algorithm or checklist, as applicable.

The advantage of using ICTs in situations specific to the speciality was successfully connected and promoted by solving manufacturing situations through virtual environments.

The multidisciplinary skills required in the workplace are demonstrated by interacting with the part manufacturing simulation process with software management activities. With resources being reduced, the development of decision-making skills is strengthened, which is something that characterizes graduates from public educational institutions.

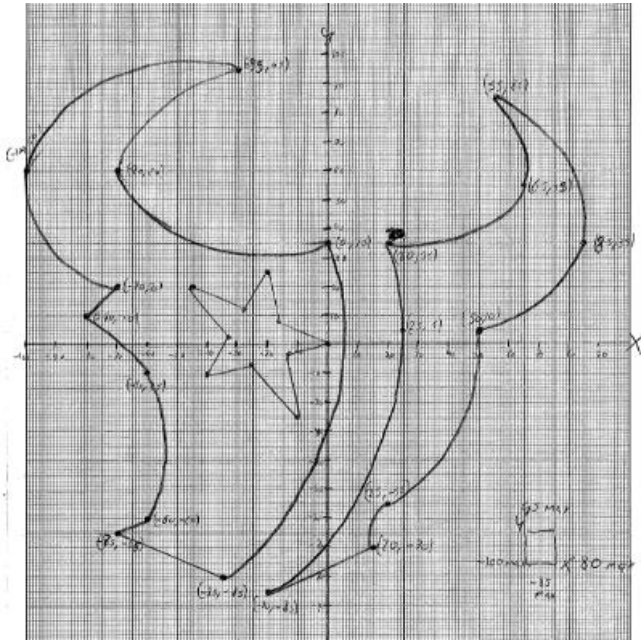
Weaknesses [areas for improvement]

Students require greater preparation in the use of computer equipment and the general management of ICTs, given that it is a step backwards to return to teaching basic points such as turning a computer on and off, saving files, among other points, and this in parallel with the recovery of prior knowledge.

It was discovered that the student does not have a work methodology, despite the fact that, upon entering this module, he already had experience with conventional lathes and milling machines, which makes it difficult for him to adapt to linear thinking that would facilitate his understanding of the virtual environment of the numerically controlled milling machine and lathe. At the student's request, teaching will be slower and more detailed, due to the above-mentioned reasons.

Methodology

In order to begin the work plan, we will start by defining the active methodologies referred to, such as the flipped classroom and project-based learning. In reviewing the literature, we find that Espinosa [2022] argues that the elements of the flipped classroom model can be consolidated into three, according to their use [see Figure 2]: 1. Simple model: through lessons at home via videos. Tasks are carried out during class by resolving doubts and questions. 2. Observation model: The home lesson adds questionnaires with information and forums for questions. 3. Innovative model: Adds micro-activities to the home lesson based on the proposed video, uses the results of class activities, allowing for the restructuring of the proposed questionnaires and forums for questions.

Box 3**Figure 5**

Millimetre sheet for the start of programming

Source: Own elaboration

Results

By applying the active Flipped Classroom methodology, students reduced the stress of having to take notes throughout an entire class and focused more on following the operation and programming, details of interaction with the basic menu, which significantly reduces the learning curve by being oriented towards more practice. See Figure 4, which represents a programmed and correctly compiled piece.

Through the PBL methodology, combined with direct instruction, the students worked in teams to solve the problem of programming the piece and, by following the sequence, were able to collectively complete the proposed challenge [programming the piece]. See Figures 2 for the CNC lathe and Figure 5 for the milling machine.

Conclusions

Simulators are effective complements between theory and practice in contexts with limited resources, but they require pedagogical and instructional support to bridge digital divides.

Links with higher education and/or business institutions enrich the experience by exposing students to real challenges [e.g., non-simulated machine adjustments].

As an area of opportunity, we suggest implementing introductory workshops on digital literacy and project methodologies from the first semesters onwards.

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 reported article.

Contribution of the authors

*Estrada-Castillo, Francisco Javier*_ Research and main idea

Castillo-Flores, Esther Saraí: Research and format

Fernández-García, Luis Guillermo: Research and methodology

Esteve-Hollinger, Blanca Rosa: Research and format.

Availability of data and materials

The simulator used by the students is SWANSOFT software, which can be found at <https://swansoft-cnc-simulator.software.informer.com/download/>. Within this software, the GSK 980Td CNC lathe emulator is used.

In addition, FAGOR software is used, which has a CNC lathe and milling machine, and can be downloaded from its website <https://www.fagorautomation.com/es/documentacion/>

Teaching materials:

Theoretical support materials include ISO coding manuals and equipment manuals for demonstration purposes, available online in various formats.

Collaborations:

The faculty has agreements with workshops and universities to attend demonstration practices.

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Abbreviations

ABP	Project Based Learning
TIC	Information and Communication Technologies

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Basics

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Supports

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Metacognitive abilities and the development of mathematical thinking

Las capacidades metacognitivas y el desarrollo del pensamiento matemático

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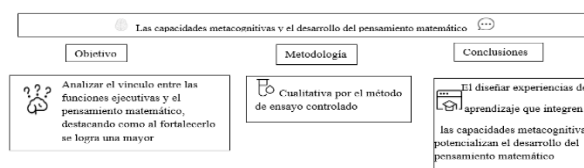
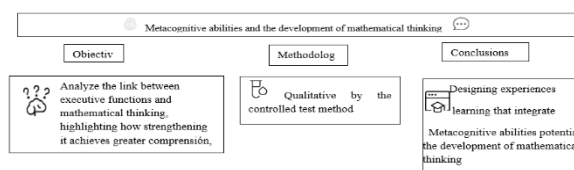


Abstract

The development of mathematical thinking requires much more than the acquisition of content; it involves the activation of complex cognitive processes that allow us to analyze, plan, solve, and reflect on problematic situations. In this context, executive functions—such as working memory, cognitive inhibition, and mental flexibility—play a fundamental role in facilitating self-regulation, strategic decision-making, and adaptation to new problem-solving conditions. This article analyzes the link between executive functions and mathematical thinking, highlighting how strengthening them contributes to deeper understanding, logical reasoning, and the ability to model real-life situations. A didactic integration of these functions in the classroom is proposed, based on institutional competencies, to promote meaningful learning and the development of higher-order cognitive skills. The proposed research methodology was qualitative, using a controlled trial method.

Resumen

El desarrollo del pensamiento matemático requiere mucho más que la adquisición de contenidos; implica la activación de procesos cognitivos complejos que permiten analizar, planificar, resolver y reflexionar sobre situaciones problemáticas. En este contexto, las funciones ejecutivas — como la memoria de trabajo, la inhibición cognitiva y la flexibilidad mental — juegan un papel fundamental al facilitar la autorregulación, la toma de decisiones estratégicas y la adaptación a nuevas condiciones de resolución. Este artículo analiza el vínculo entre las funciones ejecutivas y el pensamiento matemático, destacando cómo su fortalecimiento contribuye a una comprensión más profunda, al razonamiento lógico y a la capacidad de modelar situaciones reales. Se propone una integración didáctica de estas funciones en el aula, con base en competencias institucionales, para favorecer el aprendizaje significativo y el desarrollo de habilidades cognitivas de orden superior. La metodología de investigación propuesta fue cualitativa por el método de ensayo controlado.



Executive functions neurocognition

Funciones ejecutivas neurocognición.

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

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Introduction

Metacognitive abilities, also known as **executive functions**, are, as Bernal, 2023 mentions, a series of higher-order processes that allow individuals to focus and maintain attention, solve problems, adapt to different contexts, exercise self-control and discipline, etc. Metacognitive abilities play a crucial role in the development of mathematical thinking, including working memory, inhibition, cognitive flexibility, planning, and monitoring or self-control. These cognitive skills enable students to plan, organise, monitor, and solve mathematical problems efficiently, thereby regulating higher-level cognitive processes Bernal, 2024

Inhibition, as part of executive functions, is the cognitive ability to curb automatic impulses [impulse control], irrelevant thoughts [cognitive inhibition], inappropriate behaviours [behavioural inhibition], or filter out irrelevant stimuli to maintain the student's attention [attentional inhibition], thereby promoting adapted and conscious responses to a given situation. Diamond, 2013

The importance of inhibition in the development of mathematical thinking is that: It facilitates the resolution of complex problems by avoiding classroom interruptions. It allows strategies to be evaluated before acting, optimising decision-making. It helps to maintain students' attention during prolonged or cognitively demanding tasks. Bernal, 2023

The second executive function that has an impact on mathematical thinking is *working memory*, which allows information to be temporarily retained and manipulated. It is essential for performing mental mathematical operations, following sequential instructions, or solving complex problems, acting as a temporary storage system that keeps information active while cognitive processing is taking place. Hernández, 2021

As Bernal, 2024 points out, another important executive function is *cognitive flexibility*, which facilitates changing strategy when faced with a mathematical problem, adapting to new rules, or correcting errors. This ability is fundamental to solving mathematical problems, as it arises from the prefrontal cortex and other specific areas of the brain, meaning that cognitive flexibility activates large areas of the brain, as Bernal, 2024

Suggests.

Planning within executive functions involves organising steps and selecting methods for solving problems. It is especially useful in long or multi-step tasks, such as calculations with fractions or algebra Bernal, 2024

Finally, metacognitive monitoring or self-control refers to the ability to review work, evaluate progress, and detect errors. It is crucial for validating mathematical solutions and adjusting strategies. Trías, 2024

As Pomanhuacre, 2024 describes, assessing executive functions in students involves using tools that allow for the observation and measurement of skills such as working memory, planning, inhibition, cognitive flexibility, and monitoring. Buller, 2010 explains that among the tools for assessing executive functions are standardised neuropsychological tests such as:

The *Stroop Test*, which assesses inhibitory control by asking the student to name the colour of a word that represents another colour.

The *Tower of London*: Measures planning and problem solving by organising coloured balls on rods.

Wisconsin Card Sorting Test: Assesses cognitive flexibility and the ability to change strategy in the face of new rules.

BANFE-2: A neuropsychological battery that assesses multiple executive functions in academic contexts.

Behavioural questionnaires, as Ramos, 2019 suggests, are other tools that assess executive functions and allow information to be obtained from different perspectives [teacher, family, student]. These include:

EFECO, which is a multi-source questionnaire that assesses eight indicators such as planning, working memory, inhibition, and emotional control.

BRIEF [Behaviour Rating Inventory of Executive Function]: Widely used in school settings to detect executive difficulties in children and adolescents.

Torralvo, 2019, states that *dynamic and observational assessments* can be carried out in two ways: as *direct observation* in tasks that require organisation, problem solving or self-control, and as *performance analysis* in activities such as mathematical problem solving, reading comprehension or collaborative work.

Consequently, the above information raises the question: What activities promote executive functions in the classroom?

Valiente, 2024 proposes that executive functions are developed in mathematics classes through several alternatives.

- I. *Solving contextualised problem situations* where the student: Plans the sequence of steps, identifies variables and evaluates different strategies to arrive at the result.
- II. *Teaching sequences that involve decision-making.* An activity in which students must decide which method to use to solve a system of equations, justifying their choice.
- III. Use of assessment tools where students determine their performance. *Self-assessment and co-assessment.*
- IV. Maths activities or projects that require *planning* using a graphic organiser such as a Gantt chart or other process development tool.
- V. Exercises with *changing rules*: the teacher gives the answer and the student must find the starting expression; halfway through the activity, the instruction is reversed, which promotes cognitive flexibility.
- VI. Activities in which the student must research and summarise information within a certain time, thereby developing their **mental fluency and dual execution**.
- VII. When *modelling real situations*, such as in problem-solving, the student requires **reasoning, working memory and decision-making**.

Benefits of applying activities that develop executive functions in upper secondary school students:

Among the most relevant benefits are:

- Improved sustained attention, i.e. the student can concentrate for longer periods of time.
- Strengthening of working memory, which facilitates following instructions and solving complex problems.
- Increased cognitive flexibility, thanks to which students adapt more easily to changes by finding alternative solutions.

It promotes planning and organisation in various collaborative tasks, where the contribution of ideas must be respected.

All of the above consequently reduces impulsivity and the series of errors that this premature response can generate, gradually producing **emotional self-control**. This is vital for upper secondary school students, who, in addition to their low level of prior knowledge, mostly suffer from **social anxiety**, which makes it impossible for them to participate actively in class, either individually or collaboratively in work teams.

The aforementioned activities also *allow students to develop resilience*, enabling them to face challenges more independently. Furthermore, they learn to monitor their own progress, generating independence in their academic performance; they improve their ability to make conscious and reasoned decisions and, therefore, increase their motivation for work and study, all of which contributes to their comprehensive training as individuals who will enter the workforce or the next academic level.

Development

As an intervention proposal, the following teaching sequence is proposed for a differential calculus class at the upper secondary level, including the development of **executive functions** as part of the teaching-learning process.

Subject: Differential calculus

Level: Upper secondary

Duration: 3 modules of 90 minutes

Topic: Derivatives as a rate of change.

Activity: *Cost changes: an easy decision?*

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Competencies to be developed: Mathematical logical thinking, problem solving, decision making.

Objectives:

- Understand the concept of the derivative as a rate of change.
- Apply the derivative in real economic situations.
- Develop executive functions such as planning, working memory, cognitive flexibility and inhibitory control.

Box 1

Table 1

Integration of executive functions

Executive function	Activity to be carried out
Planning	Draw up a timetable to solve an economic problem with derivatives.
Working memory	Retention and application of basic derivative formulae in different contexts.
Cognitive flexibility	Change of strategy in the face of problems with different types of functions.
Inhibitory control	Avoid errors in the calculation of derivatives by arguing the answer with coherent and consistent procedures.

Activities per module:

Module 1 Introduction and contextualisation.

Beginning: A contextualised problem situation in the economic sphere is presented.

Development: Through guided discussion, it is determined how the derivative can represent the change in costs.

Conclusion: Write a reasoned reflection on the decision-making process that would be established for the problem situation.

Module 2 Mathematical metacognition.

Beginning: Solve problems with polynomial and exponential functions in order to practise applying derivative formulas.

Development: Collaboratively, the team chooses a solution strategy that can be applied to the problem situation they are solving.

Closing: Co-evaluation of team members using an assessment tool that evaluates the reasoning and accuracy of the mathematical algorithm used to solve the exercises. [Tekman](#)

Module 3. Integrative project.

Beginning: Design of a research summary in which students argue for the modelling of the economic situation using derivatives.

Development: Presentation with a timeline, graphical analysis, and argumentation of decision-making.

Closing: Evaluation process using an assessment tool aligned with the competencies declared by the institution in question. [Prot-Mandelbrot, 2020](#)

The assessment tool proposed is a rubric that includes both mathematical performance and the development of executive functions.

Table 2 shows both the criteria to be considered and the expected achievement.

Box 2

Table 2

Rubric for evaluating the activity: Cost shifting - an easy decision?

Criterion	Expected achievement
Understanding of the concept of derivative.	Identifies and argues the reason for change located in the contextualised problem situation.
Application of the derivative concept.	Solves problems correctly and congruently, arguing the choice of the method to solve the situation.
Planning and organisation.	Presents a detailed chronogram for the sequence of steps to solve the integrative project.
Cognitive flexibility.	Changes strategy effectively when faced with new or more complex problems.
Working memory.	Uses correct formulas and algebraic procedures in functions with different characteristics.
Inhibitory control.	Collaboratively respects and contributes ideas to reduce procedural errors, which allows them to argue in an optimal way the mathematical decisions made.
Presentation of the final project	Communicates mathematical ideas clearly using graphical and symbolic representations.
Self-evaluation and reflection	Reflects critically on their process of understanding and application of the knowledge studied.

It is important when carrying out any evaluation instrument to align the three elements that are being considered, in this case: Curriculum - Executive functions - Exit capacities of the institution. Thus, for this particular case, the alignment matrix set out in table 3 is obtained.

Box 3

Table 3

Alignment matrix

Element of the sequence.	Criterion of the rubric.	Indicator of the learner profile.
Introduction to the concept of derivative.	Understanding of the concept of derivative.	Understands the concept of the derivative as a rate of change and applies it in real contexts.
Project timeline.	Planning and organisation.	Develops logical and heuristic thinking to structure solutions.
Change of strategy in the face of various problems	Cognitive flexibility	Applies different strategies to solve complex mathematical problems.

This alignment must be considered to ensure that what is being assessed is consistent with what is stated in the curriculum and that metacognitive abilities or executive functions are indeed being correctly linked to the curriculum in question. [Verzini, 2021](#)

Results

Following the development of the teaching sequence and the subsequent application of the assessment tool, a higher percentage of students achieved a score above 8 in the diagnostic exit assessment applied to all upper secondary students at our institution.

Conclusions

The application of metacognitive skills, also known as executive functions, in mathematics classes strengthens learning, develops mathematical thinking, and enhances cognitive skills necessary for professional and academic life.

By designing activities that integrate various processes such as planning, cognitive flexibility, working memory, and inhibitory control, meaningful learning is achieved in students, promoting a reflective and functional experience.

These skills help students to independently and effectively tackle the challenges of academic thinking, such as problem solving, optimal decision making, and interpreting models in real-life contexts.

Integrating executive functions into mathematics lessons also enables students to apply knowledge critically, ethically, and strategically.

The development of executive functions is not simply a pedagogical innovation; it is a proposal for a more comprehensive education that is conscious of and connected to the demands of today's society.

Conflict of interest

The authors declare that they have no conflict of interest. The content of this article has no financial interest and is based on our experience as student trainers.

Contribution of the authors

Sánchez-López, Guillermina: author and editor of the article.

Salgado-Suarez, Gladys Denisse: method and style reviewer.

Conde-Sánchez, José Rubén: implementation and analysis of results.

Moreno-Aguilar, Ma. Antonia: implementation and analysis of results.

Availability of data and materials

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Background

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Impact of the dual training model on graduates of technological degrees: Case of The Technological University of the South of the State of Mexico [2019-2024]

Impacto del modelo de formación dual en egresados de carreras tecnológicas: Caso Universidad Tecnológica del Sur del Estado de México [2019-2024]

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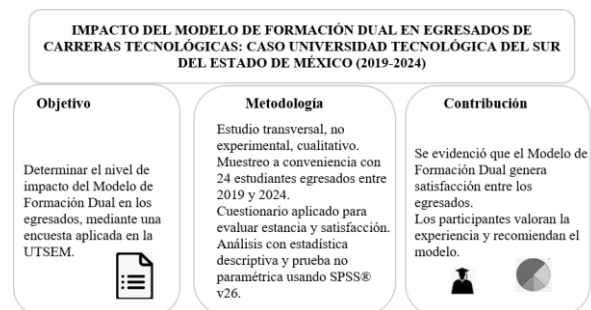
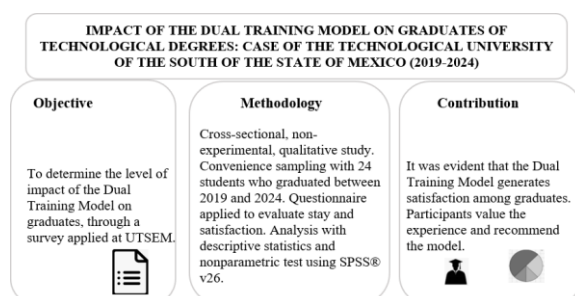
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Abstract

Objective: To determine the level of impact of dual training on participating graduates by conducting a survey to measure its reach at UTSEM. **Methodology:** A cross-sectional, non-experimental, qualitative study with convenience sampling. A questionnaire was administered to 24 students participating in the Dual Training Model from 2019 to 2024, collecting data on their experience and assessing their satisfaction. The analysis was conducted using descriptive statistics and a nonparametric test, using SPSS® v26. **Results:** Of the responses, 62.5% were graduates of the Information Technology program, 20.8% of the Food Processing program, and 16.7% of the Mechatronics program. The students participated due to the experience gained and are satisfied with the model. **Conclusion:** From 2019 to 2024, more than 50 students participated in this program. The students participated due to the opportunities the model offers and recommend it.

Resumen

Objetivo: Determinar el nivel de impacto de la formación dual en los egresados participantes aplicando una encuesta que dimensione el alcance tenido en la UTSEM. **Metodología:** Un estudio transversal, no experimental, cualitativo con muestreo a conveniencia. Se aplicó un cuestionario a 24 estudiantes participantes en el Modelo de Formación Dual de 2019 a 2024, recolectando datos sobre su estancia y evaluando su satisfacción. El análisis se realizó con estadística descriptiva y prueba no paramétrica, empleando SPSS® v26. **Resultados:** De las respuestas, 62.5 % fueron egresados de la carrera de Tecnologías de la Información, 20.8 % de la carrera de Procesos Alimentarios y 16.7 % de la carrera de Mecatrónica. Los estudiantes participaron por la experiencia obtenida y están satisfechos con el modelo. **Conclusión:** Desde 2019 hasta 2024, más de 50 estudiantes participaron en este programa. Los estudiantes participan por las oportunidades que ofrece el modelo y lo recomiendan.



Survey, Dual Training, Satisfaction

Encuesta, Formación Dual, Satisfacción

Area: Dissemination and universal access to science

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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

In Mexico, bachelor's degree programmes offered by public and private universities, technological institutes, and other institutions were in high demand at the end of the 20th century, so much so that they became insufficient to meet the requirements of industry [Weiss and Bernal, 2013]. In the 1980s, a project emerged that gave rise to the Technological University [UT] model, as a proposal to expand Dual Training Model.

The background of the dual model dates back to the Middle Ages, with origins in the craft guilds developed in Central Europe, based on the idea of 'learning by doing' under the supervision of a master. The system gave rise to the combination of education and production educational opportunities and respond to the changing situation in the country. This pedagogical model, which guided the teaching of courses at UTs, was characterized by the attributes of quality, relevance, intensity, continuity, versatility and flexibility [La Coordinación General de Universidades Tecnológicas, 2006], offering the title of Senior University Technician [TSU]. The boom was significant, and they quickly spread to several states across the country.

The result was the training of professionals with two years of preparation, responding to the needs of the industrial sector. Currently, 114 technological universities are located in the 31 states of the Mexican Republic, offering two degrees, one in TSU and the other in Engineering [Undersecretary of Higher Education, 2024], which arose from the demands of graduates to have access to higher positions in a company. In this model, links with companies are vital to ensure the practical part of the training is fulfilled, the internship, which is the student's first contact with the labour market.

The background to technological education in Mexico includes the educational models of European and North American nations. The need to cover the industrial sector and the diversification of work were factors that influenced educational policies in the last decades of the last century [Ruiz-Larraguivel, 2011] and today, the technological model has been strengthened over the last few decades, offering greater areas of knowledge.

Education is an indispensable factor for the development of economies and, therefore, for adapting to changes and new needs. In recent years, Mexico has adopted models that enable it to meet these needs. However, due to political, economic and social changes, education currently plays an important role as a catalyst for economic recovery. The amendments to the Political Constitution of the United Mexican States and the policies set out in the National Development Plan, as well as the United Nations [UN] 2030 Agenda for Sustainable Development, are in a way steering the course our country is taking with the change of government [Rodríguez, 2020].

One necessity arising from this policy is the need to train qualified professionals who will foster the relationship between businesses and educational institutions, hence the emergence of the Mexican through adaptations during the 19th and 20th centuries [Ruiz-Larraguivel, 2011].

The current dual vocational training system originated in Germany. Companies demanded changes in university education and called for greater integration of theory and practice [Palos and Herráiz, 2022], and companies such as Bosch and Daimler-Benz promoted this model. This is where the term 'dual' comes from [Morales Ramírez, 2014].

The duality of academia and business involves seeing the company as a new school, where students learn through practice in real-life situations or problems in the workplace and, by applying theoretical principles, achieve the transformation of reality [Palos and Herráiz, 2022]. In 2013, the German government made a proposal to share its experience with the dual system with interested partner countries. Thus, in 2016, European Union countries adopted the structures of the dual vocational training system. Other countries, including Mexico, are also adopting this working model [Lüber, 2022].

Dual training allows for the expansion of vocational training opportunities [Flores-Sánchez and Vigier, 2020]. The interaction between theory and practice facilitates the acquisition of skills. On the one hand, students learn interdisciplinary skills such as management, leadership and strategy, which are necessary in the increasingly complex world of work; and on the other hand, they develop personal skills such as the ability to analyze, evaluate and systematise.

It has also been observed that students acquire professional communication skills [Palos and Herráiz, 2022; Sánchez Cervantes et al., 2024].

Student learning in a practical environment is only one element of the dual model. In addition, there is a close connection between social partners, business organizations and the state, national quality standards for training content and teaching staff, and continuous evaluation [Lüber, 2022]. As a result, the dual model has been extended to several institutions, both higher education and upper secondary education, in our country [Secretaría de Educación Pública, 2014]. In the case of technological universities, incorporation begins in the fourth semester at the Higher Technical University level and in the ninth semester at the Engineering level. Thus, through collaboration, the skills acquired in educational spaces are combined with work or professional practice, which allows for the strengthening and development of aptitudes, promoting better conditions for their entry into the labour market or professional life [Government of the State of Mexico, 2019].

The Technological University of the South of the State of Mexico [UTSEM] was created in 1997 as an alternative training model consistent with the social and productive needs of the region [Technological University of the South of the State of Mexico, n.d.]. Initially offering the Higher Technical University model, in 2009, with the modification of the study plans, it extended the continuity of engineering-level studies.

The Dual Training Model at UTSEM was implemented in 2019 in accordance with the provisions established by the Government of the State of Mexico. The Mechatronics, Information Technology and Food Processes programmes, at both the Higher Technical and Engineering levels, needed to establish links with the productive sector by creating agreements to implement this model. Likewise, the government established cooperation and support links with companies located in the territory to place students in dual training [Government of the State of Mexico, 2019].

From 2019 to 2024, UTSEM has had engineering and higher technical university level students in dual training in companies in the State of Mexico and other states.

This cross-sectional study aims to determine how dual training has impacted participating students and their relationship with the workplace.

By applying a survey and conducting a correlational analysis, the study aims to gauge the scope of the implementation of this model at UTSEM, as well as to make a projection for extending it to future generations.

Methodology

This is a cross-sectional, non-experimental, qualitative study with convenience sampling. The key variables to be measured were identified, such as the students' experience in the company during their participation in the Dual Training Model; their perception of the skills developed and knowledge learned; difficulties encountered during their participation; as well as their overall perception during the period in the company and their satisfaction.

Sample selection and survey design.

All students in the Food Process Engineering, Mechatronics, and Information and Communication Technologies programmes who participated in the Dual Training Model from 2019 to 2024 at the TSU and engineering levels were selected.

Questions were formulated related to identified variables [Table 1 in the annexes] and were grouped in a logical and coherent manner to facilitate understanding and response by the respondents. Likert scales were used in some questions to measure perceptions on a scale of 1 to 5 [1 very poor, 2 poor, 3 average, 4 good and 5 excellent], as well as open-ended questions to obtain more detailed information. The survey consisted of 21 questions in electronic format, which were sent by email obtained from the UTSEM technology degree database.

The online platform Google Forms was used to administer the survey and reduce the time required to complete it. The survey was conducted during April and May 2024. Participants were given instructions on how to complete the survey and assured that their responses would be used solely for research purposes, maintaining confidentiality.

Data analysis. We began with a descriptive analysis of the variables, calculating frequencies and percentages for the responses to the closed questions [response frequency/total responses*100]. This analysis allowed us to examine the distribution of responses and the prevalence of certain opinions or perceptions among participants. Open-ended questions were divided into keywords, classifying responses according to the extent to which they mentioned the word. For Likert scale questions, the means and standard deviations corresponding to each were calculated. This provided a measure of the central tendency and dispersion of responses.

In addition, the non-parametric Kruskal-Wallis H test was performed to explore possible differences between groups [a non-parametric statistical test used to compare three or more independent groups and determine whether they come from the same distribution or whether there are significant differences between them; it does not require the data to follow a normal distribution]. The null hypothesis was that there was no variability between the scores of the participating courses at an α of 0.05. SPSS® version 26 was used for the statistical analysis.

Results

The electronic form was sent to 52 students registered at the university as participants in the Dual Training Model until 2024. A total of 24 responses were recorded, corresponding to students from the degree programmes included in the study and taught at UTSEM. Twenty-eight did not respond to the survey. Table 2 shows a summary of the characteristics of the respondents.

Box 1

Table 2

Descriptive data on participants

Distribution of responses	62.5% Technology 20.8% Food Processing 16.7% Mechatronics	Information
Sex	62.5 % men 37.5 % women	
Level at which they participated	20.3 % in TSU 16.7 % in both	

The responses were obtained from students enrolled in TSU or Engineering programmes between September 2019 and April 2024.

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The most representative percentages were 67% for 2023 and 16.7% for 2019. Others were 8.3% in 2021 and 8.3% in 2022. There were no responses from 2020 and 2024. In 2020, due to the Covid-19 pandemic, the incorporation of students into the programme was suspended, and those who were already enrolled were withdrawn for health reasons.

Normally, the programme enrolment period is in September, so when this study was conducted in April-May, the call for applications for 2024 had not yet been opened. It is important to mention that the selection of students to participate in the programme meets certain criteria, such as: their interest in participating after an introduction to the model, a socio-economic study and a psychological study, all of which are carried out at the university. Another criterion is an interview with the company's human resources department.

The preliminary selection is made by direct invitation to students who are regular university students and have outstanding academic performance. The students' graduation average confirms the above, with 69.6% having an average above 9.0 and the rest having grades between 8 and 8.9. The university has records showing that engineering students decide to participate in the programme in order to seek better job opportunities upon graduation.

In the open-ended questions, students were asked about some important aspects of their participation in the programme. In response to the question, **What were your reasons for joining the Dual Training Model?** the answers were classified into the following keywords: opportunity, experience, knowledge and work.

The search for experience was the most frequently mentioned, with 17 responses, followed by knowledge [4], opportunity [2] and work [1]. One response stood out: 'The reasons I decided to stay in the Dual Model are because the company I work for offers many opportunities to build on what I learned at university and to acquire new knowledge.'

When asked, 'How did you decide to participate in the Dual Training Model?', several points were taken into account, among the most important of which were future prospects, acquiring more knowledge, the advantages offered by the model, opportunity, convenience, experience, and mere personal interest.

One student's contribution stands out: 'The main reason was to gain experience and the opportunity for growth in the company.'

When asked if they received financial support during their stay, 70.8% said that the company provided support and 29.2% said no. Satisfaction during the stay at the company is important because it shows how satisfied the student was. In response to the question, 'How would you rate your stay at the company where you were collaborating in the Dual Training Model?', the Likert scale showed that more than 80% were satisfied with good to excellent. Figure 1 shows a graph illustrating the responses on the scale. More than 80% rate their participation as good to excellent.

Box 2

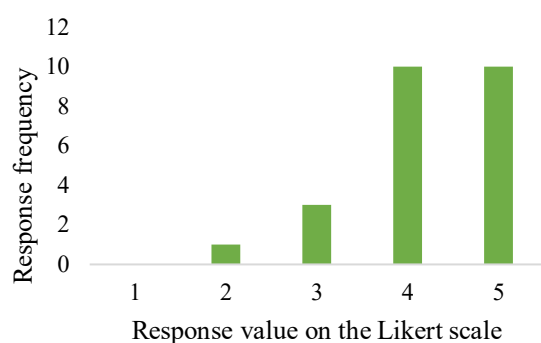


Figure 1

Evaluation of the stay in the company

In the question, How was your learning in the company, referring to learning in general, not distinguishing between knowledge, more than 80 % indicated that it was good to excellent, as can be seen in figure 2

Box 3

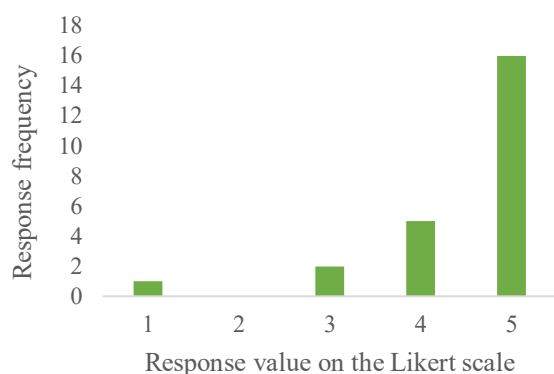


Figure 2

Satisfacción del aprendizaje en la empresa

Regarding knowledge training [knowledge], the question: How do you rate your knowledge training in the company, more than 90 % rate it as fair to excellent. Figure 3 shows the scale of responses.

Box 4

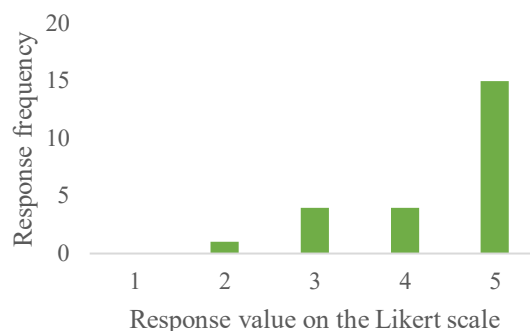


Figure 3

Satisfaction with knowledge formation

For the evaluation of the know-how developed during the stay in the company during the participation, with the question "How do you rate your know-how skills with respect to your professional profile? 79.2 % rate this participation from good to excellent".

Box 5

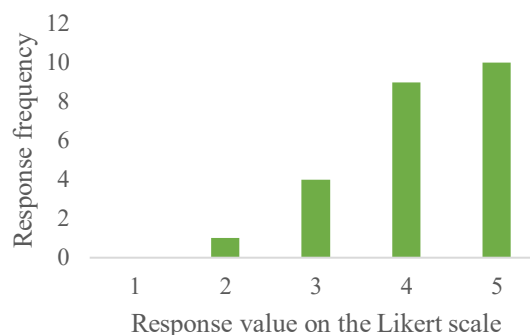
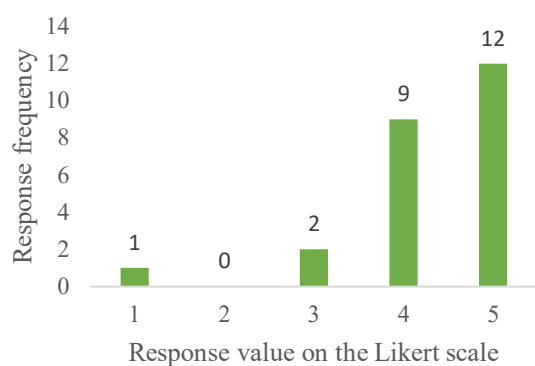


Figure 4

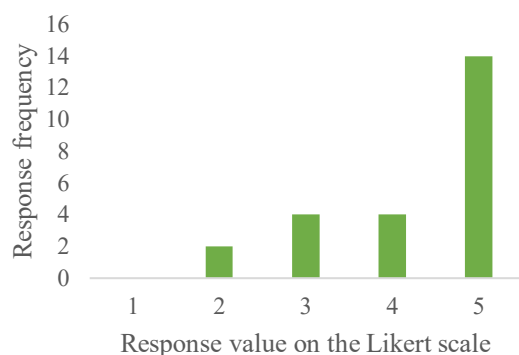
Satisfaction with know-how skills according to the professional profile

For the evaluation of the Self, 2 questions were asked: How do you rate your personal ability to cope in the current working environment? and How do you rate your personal development during your stay in the company? in both questions 87.5 % between good and excellent were mentioned.

Box 6**Figure 5**

Satisfaction regarding personal skills and personal development

With the question **"How satisfied are you with the company in which you participated in the Dual Training Model?"**, the Likert scale showed that 58.3 % rated it as excellent, 16.7 % as good, 16.7 % as fair and 8.3 % as bad.

Box 7**Figure 6**

Satisfaction with the company

We see that most participants rated their stay as good to excellent, but the percentage that rated it as poor would be a point to review in order to better monitor participation in the model. In the Likert scale questions, using the Kruskal-Wallis test to compare groups [degree programmes] to see if there was a difference, the result showed that there is no difference between the groups; the responses are highly similar.

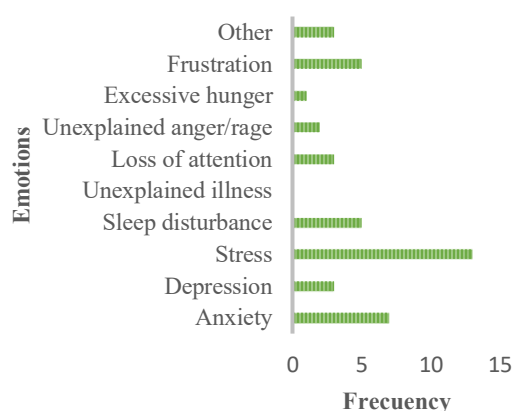
Box 8**Table 3**

Test statistic by groups

Test/question	How was your ability to cope in the work environment?	How would you rate your personal knowledge today's training in the company?	How would you rate your knowledge in the company?
H de Kruskal-Wallis	3.411	3.138	5.174
G.L.	2	2	2
Sig. asintótica	0.182	0.208	0.075
a. a.	Kruskal Wallis test		
b. b.	Grouping variable:		
	race		

Source: Own elaboration

During your participation in the Dual Training Model, participants felt some negative emotions, which are summarised in the following graph.

Box 9**Figure 7**

Perception of emotions during participation

It has been observed that when students change context, leave university and face new challenges, they may experience both positive and negative emotions. Of those surveyed, 20.8% considered the possibility of dropping out of the Dual Training Model at some point, while 79.2% did not. Stress and anxiety are two of the most common emotions experienced.

As mentioned earlier, many participated in the Dual Training Model because of the advantages it offers, such as a job opportunity in the company with which they collaborate. At the end of their participation in the Dual Training Model, only 33.3% were hired by the company and 66.7% were not.

This is understandable, as many students participate in the dual programme while studying at the TSU level, then decide to return to their studies to continue their training. Most of the graduates hired were at the engineering level. Once they had completed the Dual Training Model, 100% of those surveyed would recommend the Model to their acquaintances.

This coincides with the overall satisfaction rate of over 80%. Everyone sees it as a good opportunity and experience, regardless of the technological area of their professional profile or the degree they have studied.

Conclusions

Participation in the Dual Training Model by students studying technology-related degrees at UTSEM, specifically Mechatronics, Food Processing and Information Technology, has been generally satisfactory. From 2019 to 2024, more than 50 students participated in this programme. The Information Technology degree programme has had the most students in the programme.

During their participation in the model, students complete their training in the areas of knowledge, know-how and, therefore, being, which gives them good opportunities in the workplace once they graduate, as a large percentage of them are hired by the company where they did their collaboration.

During their participation, they face situations that require them to adapt and be resilient, successfully completing their placement, which is reflected in the overall satisfaction index of their participation in the model, which has a medium to high impact.

The dual training model benefits not only the participating students, but also their mentors, as well as the company and the educational institution itself.

Therefore, it would be interesting to review how much the characteristics of the company and the role of the dual mentor influence the conclusion and satisfaction of the participant's stay in this model.

Appendices

The following is the survey form sent for this study

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Box 10

Table 1

Questionnaire for the analysis of the Dual Training Model at the Technological University of the South of the State of Mexico.

1. Year in which you participated in the Dual Training Model
2. Age [current age].
3. Gender.
4. Degree programme you studied at UTSEM
5. Overall grade point average upon graduation or current
6. Are you currently studying or working?
7. What were your reasons for joining the Dual Training Model?
8. How did you decide to participate in the Dual Training Model?
9. Did you receive financial support from the company or a scholarship during your participation in the Dual Training Model?
10. On a scale of 1 to 5, with 1 being very poor and 5 being excellent, how would you rate your time at the company where you were working as part of your participation in the Dual Training Model?
11. On a scale of 1 to 5, with 1 being very poor and 5 being excellent, how was your learning experience at the company?
12. On a scale of 1 to 5, with 1 being very poor and 5 being excellent, how would you rate your personal ability to function in the current work environment?
13. On a scale of 1 to 5, with 1 being very poor and 5 being excellent, how would you rate your knowledge training at the company?
14. On a scale of 1 to 5, with 1 being very poor and 5 being excellent, how would you rate your development during your time at the company while participating in the Dual Training Model?
15. On a scale of 1 to 5, with 1 being very poor and 5 being excellent, how would you rate your skills and know-how in relation to your professional profile?
16. On a scale of 1 to 5, with 1 being very poor and 5 being excellent, how would you rate your analytical skills?
17. Do you think your participation in the Dual Training Model improved any of your socio-emotional skills?
18. During your participation in the Dual Training Model, did you experience any of the following [select the most frequent]: anxiety, depression, stress, sleep disorder, illness without apparent reason, loss of attention, anger/rage without reason, excessive hunger, frustration, other.
19. During your participation in the Dual Training Model, did you ever consider dropping out? If yes, why?
20. Did the company where you participated in the Dual Training Model hire you at the end of the year?
21. Would you recommend to your friends who are studying for a university degree that they take part in the Dual Training Model?

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no financial interests in conflict or known personal relationships that could have influenced the article presented in this work.

Contribution of authors

Hernández-Domínguez, María del Rosario: I contributed with the idea and development of the research.

Astivia-Arellano, Félix: I contributed to the review and editing.

Availability of data and materials

The data sets used or analysed during this study are available upon reasonable request from the corresponding author.

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Abbreviations

UTSEM	Technological University of the Southern State of Mexico
TSU	University Senior Technician
CGUT	Coordination of Technological Universities
SEP	Ministry of Public Education
UN	United Nations Organisation
G.L	Degrees of Freedom, <i>in a statistical study</i>

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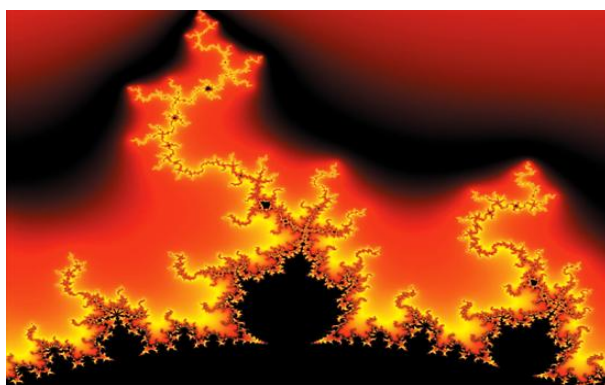


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Conclusions

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Annexes

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

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Funding

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Acknowledgements

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

Abbreviations

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ANN Artificial Neural Network

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