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Journal Applied Computing

Definition of the Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Engineering and Technology, in Subdisciplines of systems theory, networks, business interconnectivity, corporate governance, satellite communication, connectivity, tv and transmission transmitters, microwave links, radio communications and radio receivers, radiocommunication, telephony, radio transmitters.

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Knowledge Area

The works must be unpublished and refer to topics of systems theory, networks, business interconnectivity, corporate governance, satellite communication, connectivity, tv and transmission transmitters, microwave links, radio communications and radio receivers, radiocommunication, telephony, radio transmitters. and other topics related to Engineering and Technology.

Presentation of the Content

In Issue 23, is presented an article *AI tools applied in the classroom: A new teaching approach,* by Escamilla, Regis Daisy & Martínez, Bahena Elizabeth, with adscription at Tecnológico Nacional de México – Tecnológico de Estudios Superiores de Cuautitlán Izcalli, in the next article *Technological platform for early diagnosis of scoliosis in the school-aged pediatric population*, by Sánchez-Cuapio, Iván Jesús, Vázquez-Carrasco, Yenni, Conde-Camacho, Julián and Gutiérrez-Atecpanecatl, Jonathan, with adscription at Universidad Tecnológica de Tlaxcala, in the next section *Application of Information Technology in the improvement of administrative processes: Web-based system for activating and monitoring surveys*, by Rico-Chagollán, Mariana, Rodríguez-Campos, Juan Carlos and Chacón-Olivares, María del Carmen, with adscription at Tecnológico Nacional de México [TECNM]/ Instituto Tecnológico Superior de Irapuato [ITESI], in the next section *Development of a document management system in accordance with ISO 9001:2015 for the coordination of comprehensive transportation in Irapuato* by Espinosa-Sánchez, Adriana, Vargas-Rodríguez, Bertha Laura and Cabello-Jaime, Emilio, with adscription at Instituto Tecnológico Superior de Irapuato, in the next section *Technology transfer in inventory and order management in automotive parts stores* by Sánchez-Luna, Antonio, Rodríguez-Campos, Juan Carlos and Rico-Chagollán Mariana, with adscription at Tecnológico Nacional de México [TecNM] / Instituto Tecnológico Superior de Irapuato [ITESI], in the next section *Educational IoT platform under DevOps methodology* by Montecillo-Puente, Francisco-Javier & Tapia-Muñoz, Alejandro, with adscription at TecNM campus Salvatierra, in the next section *Website of medical specialties of the region Huasteca Hidalguense* by Del Carmen-Morales, Heidi, Del Carmen-Morales, Yucels Anaí, Felipe-Redondo, Ana María and Hernández-Rodríguez, Yvan de Jesús, with adscription at Universidad Tecnológica de la Huasteca Hidalguense.

Content

Journal Applied Computing 9[23]1-7: e1923107
Article

AI tools applied in the classroom: A new teaching approach

Las herramientas de la IA aplicadas en el aula: Un nuevo enfoque docente

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Abstract

Teaching today is undergoing a whirlwind of significant changes, both in the content and in the way in which the teaching-learning process is delivered. This has led to the integration of a wide variety of technological tools that help students not only acquire knowledge, but also be able to identify how they can project these processes into research work, established improvement proposals, and generate valuable tasks that significantly contribute to promoting progress in all areas of education.

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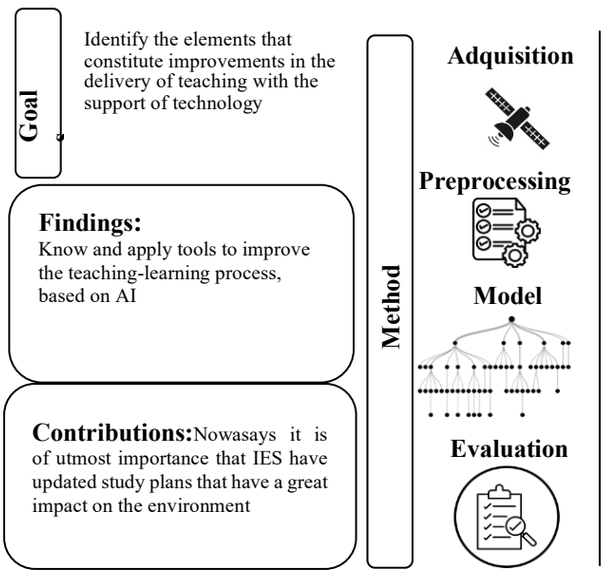
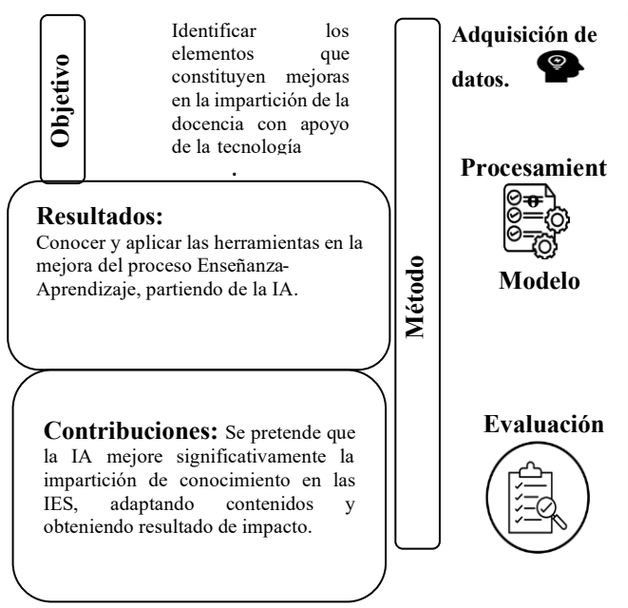


Artificial Intelligence, teaching, learning, meaningful knowledge, digital tools

Resumen

La docencia en la actualidad, está atravesando por una vorágine de cambios significativos, tanto en los contenidos como en la forma en que se imparte el proceso enseñanza-aprendizaje, ello ha dado pauta a que se puedan integrar una gran diversidad de herramientas tecnológicas que coadyuvan a que los educandos no solo adquieran conocimientos, sino además, sean capaces de identificar la forma en que pueden proyectar esos procesos en trabajos de investigación, propuestas de mejora establecidos y generar tareas de valor que contribuyan significativamente a promover los avances en todas las áreas de la educación



Inteligencia Artificial, enseñanza, aprovechamiento, conocimiento significativo, herramientas digitales

Area: Strengthening the scientific community

Citation: Escamilla, Regis Daisy & Martínez, Bahena Elizabeth. [2025]. AI tools applied in the classroom: A new teaching approach. Journal Applied Computing. 9[23]1-7: e1923107.

Introduction

Education is the foundation of knowledge, upon which the significant progress of a people, a community, and a nation depends. That is why advances in this area are essential, and this is also reflected in the content and the way it is taught, what type of resources will be used to support it, and what audience it is aimed at.

Undoubtedly, one of the great advances in recent times is the emergence of Artificial Intelligence [AI], which, although initially focused on information processing, adaptability and process improvement in companies, soon became linked to all areas of human life, with technology being one of the most favoured branches. and therefore, the emergence of various tools and applications to improve education has also undergone a drastic change.

In many ways, AI has become such a major transformation process that it has been tangibly integrated into the technological, social and economic spheres, offering task automation, increasing basic services, generating significant achievements in medicine, etc. However, it should also be noted that not everything has been for the benefit of human beings, since, along with the emergence of Artificial Intelligence, there are situations of risk in terms of job losses, inequality, discrimination within the algorithms generated in searches, security and governance.

The evolution of AI also leads us to human, social and personal evolution, transforming the way we live our daily lives. That is why we also face significant challenges involving a more complex world, where it is necessary to generate increasingly powerful and efficient technologies, while at the same time ensuring that individuals' privacy is not invaded and that ethical and legal limits on their use and application are respected and valued.

AI and Education

One of the main ideas about Artificial Intelligence is that it is a technology capable of helping to solve problems and generate meaningful learning without the need for human assistance, focusing on three aspects:

A] STUDENTS. AI has the capacity to generate educational spaces that respond to the needs of students, promoting the application of more inclusive and specialised areas of learning for the target population.

B] TEACHERS. Using AI tools in teaching has the advantage of reducing workload and allowing for more time to be spent on personalising content and generating greater adaptability when creating lessons that include tools that benefit the teaching-learning process.

C] EDUCATIONAL SYSTEMS. Some of the support provided by AI can enable the automation of curricula that meet the diverse needs of users. Personalised tutoring is another tool that can be of great help in significantly reducing school dropout and/or withdrawal rates. [Educational AI, 2024].

Box 1

Figure 1

AI and Education

Source: (IA Educativa, 2024)

However, despite the wide range of benefits that the use of Artificial Intelligence brings us, we cannot ignore the fact that there are limitations to its dissemination and access. One of the main limitations is access to technological tools. Without internet in remote areas, this causes a bias in information. Another difficulty is the reluctance of teachers to incorporate technology into the teaching process. There is still too much reliance on books and traditional education, which, although they are a significant part of education and have great scientific support, are limited to reference content, rather than access to the infinite resources that are currently available on the information superhighway.

Artificial Intelligence Tools for the Classroom.

While it is true that there are currently various resources that use AI and allow users to operate them with little knowledge of technology, it is also important to emphasise the contributions they make to their implementation in classrooms.

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It is also important to note that some are part of platforms that, although excellent in terms of content and user interfaces, are not free to access, which can further increase the difficulty of accessing the information they contain. Therefore, on this occasion, we will limit ourselves to showing some that, in our opinion, have more advantages in their implementation.

A] **NotebookLM**. It is part of the Google environment. In addition to being easily accessible, it is free and, as well as taking content that can be constantly fed into it, it gives us access to documents and information from large databases and can interpret, process and generate new content from articles, videos and other documents simultaneously. [SOCIAL MEDIA SYLLABUS, 2025]

Some of its most important advantages are that its responses are reliable, it allows content to be converted to audio, which diversifies the way in which content can be delivered, and, being a generative intelligence, it constantly feeds itself and is a free tool.

One of the disadvantages of this content is that it does not offer customisation options on the GUI and the way in which information is shared in the free mode.

Box 2

Figure 2
NotebookLM Logo
Fuente: (SOCIAL MEDIA SYLLABUS, 2025)

A] GAMMA APP. Although this tool was designed for business and collaboration, it offers many options for displaying information, creating presentations, infographics, etc. However, it is also very useful for creating lessons, multimedia content, study guides, access to interactive tasks, etc. [Gamma.app, 2025]

One of its advantages is that it allows for the inclusion of various types of formats to present the information generated, which facilitates the design process for those who create the content.

It is credit-based, so the more content that is generated, the more credit is used up, making it necessary to sign up for a payment plan.

Box 3

Figure 3
Gamma App
Source: (Gamma.app, 2025)

A] UIZARD. For more specialised users, it has a highly intuitive interface that, with just a few instructions, develops all the content, allowing you to visualise applications, complete user interfaces and redesign options that were already working, all from a very attractive environment. Among its main advantages is the fact that it greatly simplifies the creation of designs from instructional sketches and offers a wide variety of templates that are also adaptable to the user's needs. [Uizar, 2025]

One of the main disadvantages is that, in order to access all its capabilities, you have to upgrade the plan and pay for it.

Box 4

Figure 4
Uizard
Source: [Uizar,2025]

A] Ohmydots. This is a gamification tool that focuses on reinforcing classroom teaching activities. However, it has the advantage of being highly visual, which easily attracts students to participate in the activities, so it does not feel like just learning. [Ohmydots!, 2025]

Although it is a great source of feedback, this tool is limited to exercises with a linear structure, so it does not promote new projects or learning that go beyond what is proposed.

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Box 5

Figure 5

Gamification

Source: (Ohmydots!, 2025)

It is important to note that, although there is a wide variety of resources that use Artificial Intelligence to enhance content, it should be borne in mind that, even today, the vast majority require payment plans in order to obtain all their benefits. Therefore, it is necessary to identify which ones offer content that is useful for what you want to project to your students.

Why introduce AI tools into the classroom?

While it is true that there is a wealth of content on the web that can be accessed in real time, the emergence of Artificial Intelligence has been a game-changer in teaching, as, in addition to bringing us even closer to education, it has also allowed us to access countless capabilities that would otherwise result in many hours of consultation in front of technological devices.

Not to mention that allowing different ways of presenting the same information to students is a great help. The personalisation of content, as well as immediate tutoring, greatly enriches the ability to convey knowledge and ensures that it is interpreted correctly. The abstraction of content, its improvement, its translation through reinforcement activities, etc., is an infinite resource of possibilities that privilege the teaching experience, and AI undoubtedly plays a favourable role in this.

Case study: Use of Artificial Intelligence [AI] tools in the classroom. Methodology

Currently, AI tools are used in various activities and/or areas such as education, the latter being the area on which this research focuses, and which has key players, namely teachers, students and the education system. It is extremely important to identify whether these players are prepared to use the various AI tools, whether they are using and implementing them in their various areas of knowledge, as well as the benefits or disadvantages of bringing them into the classroom from their point of view.

The objective of the research will be to analyse the impact that AI tools have had on the education system, as well as which tools are most widely used.

The study was carried out at a Higher Education Institution [HEI], which offers nine engineering degrees, of which only those degrees that are most aligned with technology will be sampled, namely Systems Engineering and Technology Engineering. Both programmes have approximately 600 students enrolled and 45 teachers, who will be taken into account to carry out the research.

The research will be organised as follows: first, identifying which AI tools teachers and students use; then analysing the uses they give to AI tools; and finally, the impact this could have on the education system.

The first survey was conducted to determine whether they had ever used AI tools.

The results showed that 82% of teachers had used some AI tool and 18% had not used any.

However, in the case of students, 90% have used them and 10% have not. This indicates that the majority of both students and teachers have used AI tools at some point, as can be seen in the graph in the [Escamilla, 2025].

Box 6

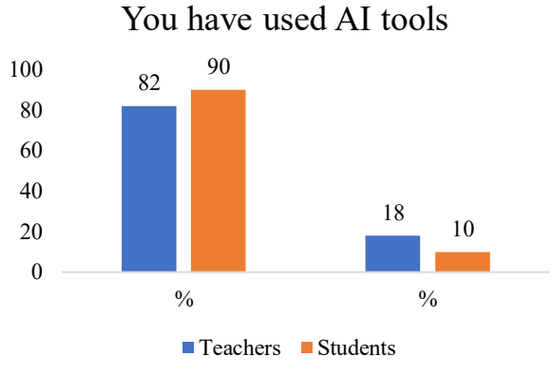

Figure 6

Graph showing the use of AI tools by teachers and students

Source: (Escamilla, 2025)

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On the other hand, to follow up on the survey, questions are asked about how these tools are used. Most teachers use them to prepare their classes, as they mention that they give them ideas to make their classes more attractive than they had planned.

Some others use them to design class materials or as support for planning classes, as well as for evaluating student work. In the following graph shown in [Escamilla, 2025], shows the percentages that are latent in class preparation, as already mentioned, since from their point of view it provides them with ideas to be more dynamic and keep students from getting bored, as they observe that it is increasingly necessary to entertain students with innovative classes and materials so that they are more attracted to each of the classes.

Box 7

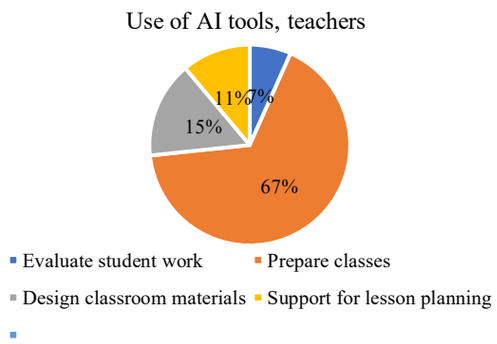

Figure 7

Chart showing various uses of AI tools from the teacher's perspective

Source: (Escamilla, 2025)

To follow up on the research, students are also surveyed to find out how they use the various AI tools, as it is extremely important to determine how they are used. Now that we have seen how AI is used from the perspective of teachers and students, it is important to look at the impact this may have on the education system, as perceived by teachers who are concerned that students using AI tools for their various academic activities may damage academic quality or student development both inside and outside the classroom.

Escamilla [2025] presents a graph from a survey of teachers which shows that, for them, the use of AI tools by students is not entirely bad, but that this may change depending on how they are used.

According to the survey, 40% of students use them for support and up to 68% use them to do all of their work. They perceive this because they realise when a student submits schoolwork done entirely by an AI tool.

Box 8

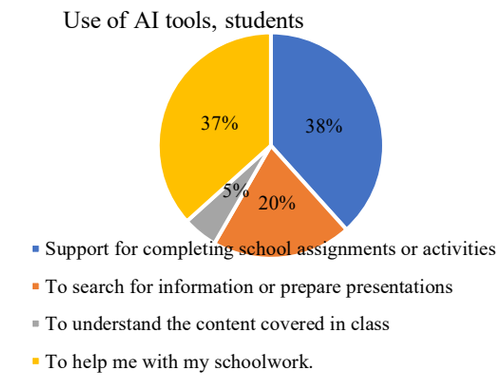

Figure 8

Graph showing various uses of AI tools from the student's perspective

Source: (Escamilla, 2025)

Likewise, 60% believe that if students make greater use of tools to complete their work in its entirety, it may affect their academic quality.

Box 9

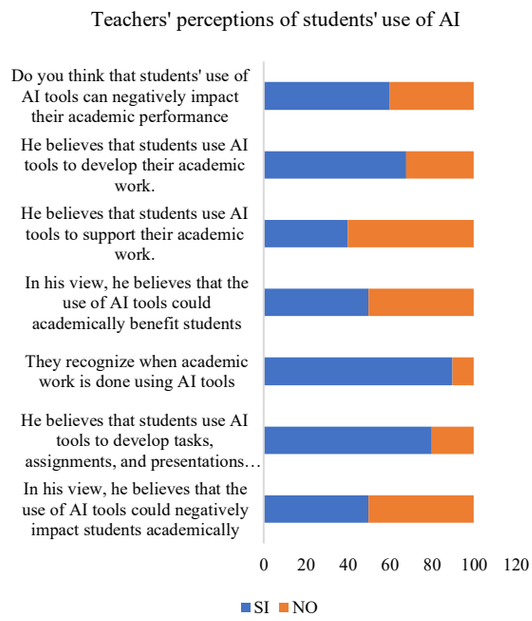

Figure 9

Graph showing teachers' perceptions of students' use of AI tools

Source: (Escamilla, 2025)

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Based on this latest survey of teachers, it can be observed that teachers do not view the use of AI tools for the development of their academic activities negatively, as long as they are used as a support, since this can broaden or deepen knowledge from various perspectives, not just those addressed in class. The problem would arise when these tools are used exclusively for development without verifying the information provided by AI, as this could lead to other issues such as a loss of analysis from the student's perspective and academic maturity in their training during their degree programme.

Results

The results based on the surveys conducted in this research process show that 86% of students and teachers are familiar with and/or have used some of the AI tools, with a large percentage of teachers mentioning that they use them to support their classes, as they provide them with ideas to make them more attractive and contribute new techniques that allow them to innovate in their classrooms and make them more engaging.

However, on the student side, the survey shows that they have a high percentage of use of these AI tools to support some of the general academic class activities, as well as using them to support them in the total solution of some other activities, perhaps making the process of developing activities easier for them.

Likewise, teachers' perception of students' use of AI tools is that they can identify when students use them as support and when they use them for total development, since teachers can detect this when assignments are handed in. On the other hand, they consider that the use of various AI tools can contribute a lot to students as long as they are used only as support.

Otherwise, in the long run, if the use of these tools by students is not controlled, instead of benefiting them, they could affect academic quality because they can gradually diminish students' learning and thus have a negative impact. Therefore, it is important to use them under strict consent as support for certain activities, which is good, but always in a balanced way.

Acknowledgements

We would like to thank the Technological Institute of Higher Education of Cuautitlán Izcalli for its financial support for this article.

Conclusions

Currently, technologies have brought great benefits in various areas, including education. but on this occasion, the tools provided by artificial intelligence have greatly supported both teachers and students, facilitating certain tasks and providing ideas for innovation. However, it is recommended that they be used as support for various academic tasks or as part of the teaching-learning process without being so invasive that academic quality is lost sight of.

Today's AI tools can be of great help in supporting the development of various activities as long as they are only a support, since leaving everything to be solved by these tools could be detrimental in the long run, especially in the field of education, since a classroom should always be innovating by providing new tools or ways of sharing and acquiring learning using the much-talked-about AI.

Declarations

Conflict of interest

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

Area of study

The study was conducted at the Higher Education Institution, as this is where the sample of teachers and students was taken in order to collect the data that was analysed, which will be used in the future to develop the proposal for the use of technological tools.

Contributions of authors

Martinez-Bahena, Elizabeth: Contributed to the foundations on which it was implemented, with the state of the art, theoretical framework, type of research, and contribution to the writing of the article.

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Escamilla-Regis, Daisy: Contributed to the main idea of the project, the type and design of the field research, the instrument, data collection and results, as well as the writing of the article.

Availability of data and materials

The images were obtained from the free platform**;** the tables and graphs are our own work, with data obtained by applying the instrument within the institution.

Funding

This work was funded by the Technological Institute of Higher Studies of Cuautitlán Izcalli.

Abbreviations

IES	Higher education institution
IA	Artificial Intelligence

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Article

Technological platform for early diagnosis of scoliosis in the school-aged pediatric population

Plataforma tecnológica para el diagnóstico temprano de escoliosis en población pediátrica escolar

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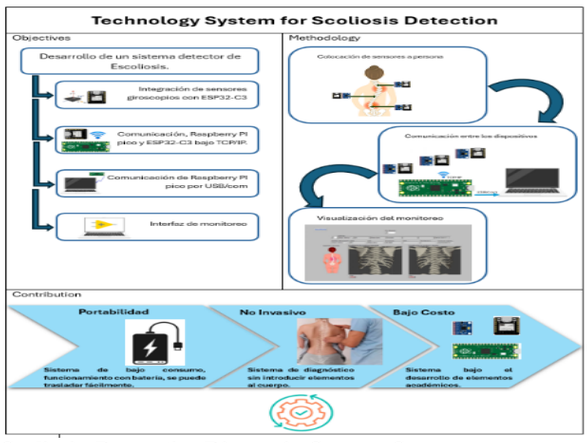
Abstract

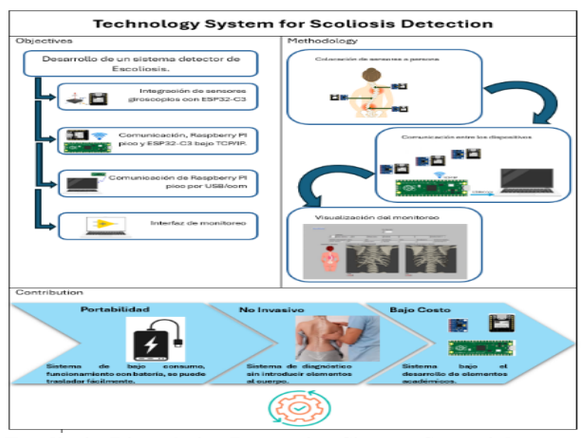
Scoliosis is a lateral deviation of the spinal column that can affect the development and quality of life of children. Early detection is essential to implement timely treatments and prevent complications. This study proposes a wireless sensory system based on inertial measurement units [IMUs] and ESP32 microcontrollers for objective, real-time detection of postural deviations compatible with scoliosis in school-aged children. Data are transmitted via Wi-Fi to a PC-based graphical interface that enables clinical information registration, visualization, and storage for follow-up. Simulated results demonstrate promising performance with sensitivity and specificity above 85%. This system represents an accessible, portable, and non-invasive tool that can complement traditional screening methods, contributing to scoliosis prevention and monitoring in school settings.



Scoliosis, Preventive Diagnosis, Sensory System

Resumen

La escoliosis es una desviación lateral de la columna vertebral que puede afectar el desarrollo y la calidad de vida de los niños. La detección temprana es fundamental para implementar tratamientos oportunos y evitar complicaciones. Este trabajo propone un sistema sensorial inalámbrico basado en unidades de medición inercial [IMU] y microcontroladores ESP32 para la detección objetiva y en tiempo real de desviaciones posturales compatibles con escoliosis en niños en edad escolar. Los datos se transmiten vía Wi-Fi a una interfaz gráfica desarrollada en PC, que permite registrar, visualizar y almacenar información clínica para el seguimiento. Los resultados del sistema muestran un desempeño prometedor con sensibilidad y especificidad superiores al 85%. Este sistema representa una herramienta accesible, portátil y no invasiva que puede complementar los métodos tradicionales de tamizaje, contribuyendo a la prevención y monitoreo de la escoliosis en entornos escolares.



Escoliosis, Diagnóstico Preventivo Sistema Sensorial

Area: Advocacy and attention to national problems

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Introduction

Scoliosis, characterized by a lateral and rotational deviation of the spinal column, represents a clinical challenge that requires early detection to prevent severe complications in patients' musculoskeletal health, especially in the pediatric population. Conventional diagnostic methods include visual assessments based on the Adams test and radiographic studies, which present limitations in terms of subjectivity, radiation exposure, and accessibility [Parent et al., 2010].

In the field of biomedical and mechatronic engineering, the development of portable and non-invasive sensory systems offers a promising solution to complement traditional diagnosis. Inertial measurement units [IMUs], which integrate accelerometers and gyroscopes, enable accurate real-time capture of movements and postures, facilitating quantitative analysis of body alignment [Bonnet et al., 2020].

The integration of microcontrollers with wireless communication capabilities, such as the ESP32, allows for efficient data transmission to personal computer-based processing and visualization platforms, enabling real-time monitoring systems and automated recording of clinical information [Molanes López et al., 2019].

This work presents the design, implementation, and validation of a wireless sensory system based on IMUs for the objective detection of scoliosis in school-aged children.

The electronic components of the system, signal processing using LabVIEW, and the software architecture for data management and clinical report generation are described. The potential of this technology to improve the efficiency and accuracy of postural screening is discussed, facilitating its application in school settings and rehabilitation centers.

State of the Art

The diagnosis of scoliosis has traditionally been approached through clinical and radiographic methods. The most commonly used tool for visual detection is the Adams test, widely applied in school settings due to its simplicity and low cost.

This procedure allows the examiner to observe trunk asymmetry when the patient performs forward bending, but its effectiveness is subject to the specialist's subjective interpretation, which limits its accuracy [Castro et al., 2010].

Diagnostic confirmation and assessment of scoliosis severity rely on spinal X-rays, where the Cobb angle is calculated—considered the gold standard for classifying the magnitude of the curvature [Vrtovec et al., 2009]. However, exposure to ionizing radiation poses a significant concern, particularly for pediatric patients who may require multiple assessments over time [Parent et al., 2010].

In response to these limitations, there has been a growing trend toward the development of non-invasive technologies that allow for objective and frequent evaluation of the spine without the need for X-rays. In this context, inertial sensors—such as accelerometers, gyroscopes, and magnetometers—have proven to be promising tools for postural analysis and monitoring of spinal deformities [Zhang et al., 2016; Bonnet et al., 2020]. These devices offer the advantages of being portable, low-cost, and capable of providing real-time quantitative measurements.

Zhang et al. [2016] developed a portable system based on inertial sensors for scoliosis detection, validated with both healthy volunteers and diagnosed patients. Their results showed a high correlation between the recorded data and clinically detected deviations, positioning this technology as a viable alternative for initial screening. Similarly, Bonnet et al. [2020] implemented a set of inertial measurement units [IMUs] in adolescents, successfully identifying abnormal postural patterns associated with scoliotic curvatures, suggesting their potential for clinical and home-based applications.

Other studies have integrated these sensors with signal processing algorithms and machine learning techniques to enhance the automatic classification of patients with scoliosis. For example, the use of artificial neural networks and support vector machines has been explored to distinguish between normal and pathological postural patterns, yielding promising results [Komeili et al., 2019].

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Despite these advances, further efforts are required to validate these systems in school environments and in studies with larger populations, especially considering their applicability as screening tools. In this regard, the development of user-friendly devices capable of reliably recording data and offering intuitive interfaces for non-specialist professionals represents a key research direction in the field of clinical biomechanics and rehabilitation.

System Design

This project follows a quantitative, experimental, and cross-sectional approach aimed at the design, implementation, and validation of a portable sensory system for the early detection of postural deviations compatible with scoliosis in school-aged children.

This approach addresses the growing need for portable, accessible, and objective technologies that complement traditional visual and radiographic assessment methods, which present limitations in terms of accuracy, subjectivity, or radiation exposure [Parent et al., 2010; Vrtovec et al., 2009]. Likewise, the study aligns with recent proposals in clinical biomechanics that promote the use of inertial sensors as valid and reliable tools for postural evaluation in school or community settings [Bonnet et al., 2020; Zhang et al., 2016].

Development and Calibration of the Sensory System

In the first stage, inertial measurement units based on MPU6050 sensors were selected and configured, integrated with ESP32 microcontrollers for data acquisition and wireless transmission via Wi-Fi. An ergonomic mount was designed to ensure the precise placement of the sensors in the thoracic and lumbar regions, guaranteeing stability and proper alignment during measurement.

A calibration protocol was implemented to ensure the accuracy and reliability of the measurements, which included:

- Laboratory tests with controlled movements to verify the response of the sensors along the three axes of acceleration and rotation [Bonnet et al., 2020].
- Validation of wireless communication, evaluating sampling rate, latency, and packet loss, with special attention to the Wi-Fi protocol on ESP32 microcontrollers [Molanes López, Fraga-Lamas, & Fernández-Caramés, 2019].
- Tuning of digital filtering algorithms and sensor fusion to optimize signal quality under real conditions, implemented in LabVIEW [National Instruments, 2020].

Field Experimental Evaluation

The second stage consisted of deploying the system in school and clinical settings to evaluate its ability to detect postural deviations indicative of scoliosis. A data acquisition protocol was defined, which includes:

- The systematic placement of sensors at standard anatomical positions on vertebrae T3 and L2, using the custom-designed mount [Topalovic, Stankovic, & Strbac, 2020].
- Data captures during static and dynamic postures using the Adams test, with time synchronization between sensors and the base station [Bonnet et al., 2020].
- The simultaneous collection of conventional clinical data to establish a reference standard [Parent, Newton, Wenger, & Mahar, 2010].

The design includes the evaluation of key technical parameters such as measurement repeatability, robustness interference, and variability in sensor placement.

Population

The target population of the project consists of school-aged boys and girls, specifically between 8 and 12 years old, who attend primary education in schools located within the area of influence of the Centro de Rehabilitación Integral [CRI] in Apizaco, Tlaxcala, Mexico.

This age range was selected because it corresponds to the period of highest prevalence and progression of infantile and juvenile idiopathic scoliosis [Weinstein et al., 2008].

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The sample is composed of students from four primary schools near the CRI, which are regularly visited by clinical staff from the center as part of their early detection campaigns.

Participant selection is carried out through non-probabilistic convenience sampling, since access to the schools depends on institutional agreements and written consent provided by parents or legal guardians.

The inclusion criteria are students aged 8 to 12 years, in physical condition to perform posture and bending tests without assistance, and whose guardians have provided written consent for their participation in the study. Exclusion criteria include children with a prior diagnosis of cerebral palsy, neuromuscular syndromes, or orthopedic conditions that interfere with normal trunk mobility.

The estimated initial sample size is approximately 40 to 50 children, aiming to represent both cases without visible signs of scoliosis and subjects with possible postural deviations. Preliminary identification will be conducted through the Adams test applied by CRI medical personnel, with the goal of comparing clinical findings with the data obtained from the sensory system. Data collection will be conducted by physiotherapists and medical specialists from CRI Apizaco, who have experience in postural screening and working with pediatric populations. The study will also ensure compliance with ethical principles for human research, in accordance with the Declaration of Helsinki and national guidelines on research involving minors [Consejo de Salubridad General, 2012].

Technical Variability in Sensor Placement

In order to evaluate the robustness of the system against potential human errors during sensor installation, repeatability protocols will be implemented, in which different operators will place the devices on a subset of participants to analyze intra- and inter-operator variability [Bonnet et al., 2020].

Technological System

The system developed for scoliosis detection is based on an integrated hardware and software architecture, designed to wirelessly capture, transmit, and record postural data in real time.

At the core of the system are inertial measurement units [IMUs], which combine accelerometers and gyroscopes to measure linear acceleration and angular velocity across three axes.

These sensors were selected for their low cost, compact size, and suitable accuracy for non-invasive biomedical applications [Bonnet et al., 2020].

Each IMU is paired with an ESP32 microcontroller, which provides embedded processing capabilities and Wi-Fi wireless connectivity. Wireless communication enables real-time data transmission to a base station [PC] without the need for cables, increasing user comfort and mobility during assessment [Molanes López, Fraga-Lamas, & Fernández-Caramés, 2019].

For attachment, an adjustable ergonomic mount was designed to ensure proper placement of the sensors in the thoracic [T3 vertebra] and lumbar [L2 vertebra] regions, minimizing motion artifacts and displacement during data collection. Figure 1 [Molanes López et al., 2019].

Box 1

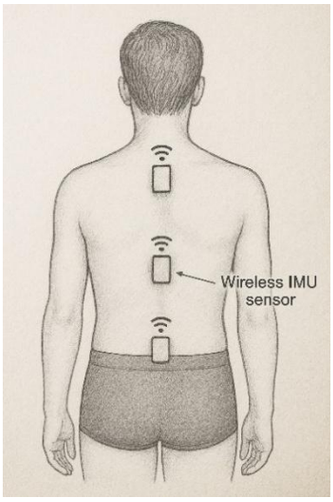

Figure 1

Positioning of the Sensory System for Scoliosis Measurement.

Source Own elaboration

This configuration allows for the capture of relative angular information between spinal segments, particularly during the anatomical position and forward bending as indicated by the Adams test, facilitating the detection of postural asymmetries. Figure 2.

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Box 2

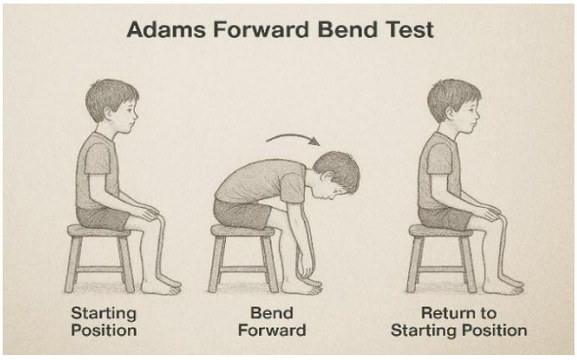

Figure 2

Application of the Adams Test for Measuring the Degree of Scoliosis.

The data collected by the sensors is transmitted via Wi-Fi protocol from the ESP32 to a central computer [PC] that acts as a base station. For this purpose, a custom graphical interface has been developed using the LabVIEW [Laboratory Virtual Instrument Engineering Workbench] environment, which allows:

- Real-time visualization of the spinal angular inclination measurements.
- Recording of participant personal data such as name, age, gender, weight, height, and date.
- Automatic capture of the degree of deviation identified by the system.
- Generation of an individual digital clinical record in PDF format, which is automatically stored in a local database.

This data management system enables not only immediate analysis during the assessment but also longitudinal follow-up of patients in cases of positive detection, providing documentary support for future clinical evaluations.

Box 3

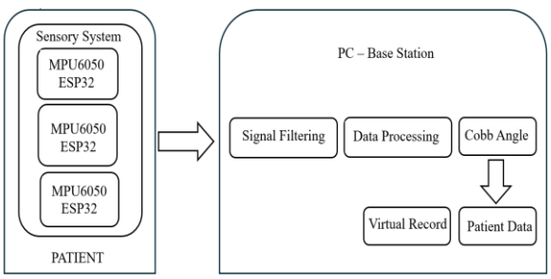

Figure 3

Architecture of the Technological System for Measuring the Degree of Scoliosis.

Source Own elaboration

The system architecture show in Figure 3 is designed to be scalable, portable, and low-cost, facilitating its implementation in school settings and rehabilitation centers without the need for specialized medical equipment. Additionally, it aligns with the concept of digital technologies applied to school health and community-based rehabilitation [Topalovic et al., 2020].

Signal Processing

The reception of data from the sensors and signal processing is performed using LabVIEW, a graphical programming software developed by National Instruments, which allows the creation of systems for data acquisition, visualization, analysis, and real-time storage. This tool is ideal for clinical and experimental environments due to its ability to integrate with standard communication protocols and its intuitive visual interface [NI, 2020].

The format of the obtained information is shown in Figure 4, illustrating the contribution of each sensor.

Box 4

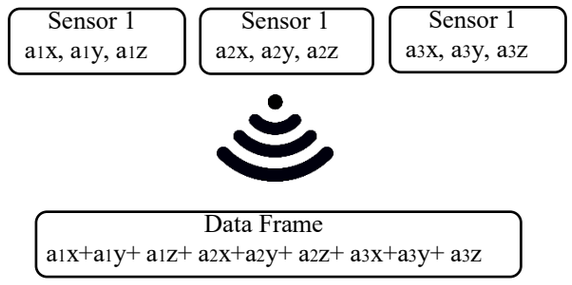

Figure 4

Data Format of the Sensory System.

Source Own elaboration

Signal Filtering

To reduce noise generated by vibrations, residual movement, or sensor errors, a 4th-order Butterworth low-pass digital filter with a cutoff frequency of 5 Hz is applied. This cutoff is suitable for removing high-frequency components not associated with postural movement, as shown in Figure 5 [Preece et al., 2009].

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Box 5

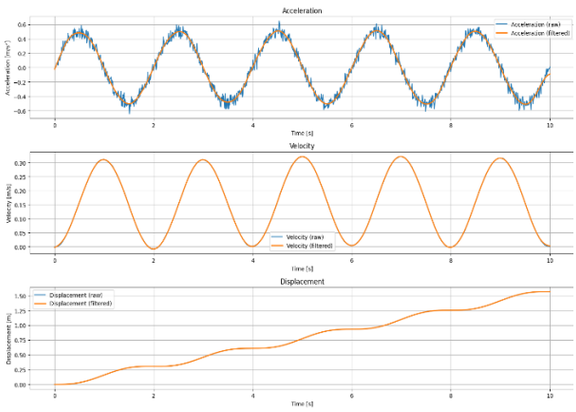

Figure 5

Filtered signal of acceleration, velocity, and displacement.

Source Own elaboration

This filter is implemented using the LabVIEW Butterworth Filter VI, either with pre-calculated coefficients or by using filter design blocks from the Signal Processing module.

Sensor Fusion and Orientation Calculation

To accurately estimate trunk inclination, a sensor fusion algorithm based on a complementary filter is applied, which combines the stability of the accelerometer with the fast response of the gyroscope.

This process allows the calculation of the relative inclination angle between the sensors located at the T3 [upper] and L2 [lower] vertebrae. The lateral inclination [roll] is of particular interest to detect postural asymmetries associated with scoliotic deviations. Figure 6.

Box 6

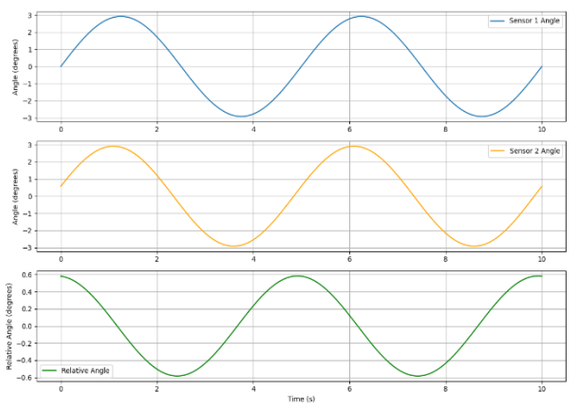

Figure 6

Calculation of the angle between sensors.

Source Own elaboration

Segmentation and Windowed Analysis

The filtered and processed data are grouped into 1-second time windows with 50% overlap. For each window, the following are calculated:

- The mean lateral inclination angle between both sensors.
- The absolute angular difference, interpreted as a deviation index $[\Delta\theta]$.
- It is recorded whether the $\Delta\theta$ value exceeds a clinical threshold of 5°, as an initial suspicion criterion [Topalovic et al., 2020].

Visualization and Storage

The system displays in real time:

- Graphs of the angles from both sensors.
- A graphical representation of the spine [postural scheme] with simulated deviation.
- A visual alert if the established threshold is exceeded.

The results are automatically stored in a PDF file associated with the previously registered patient. This file includes patient identification, date, average deviation values, and a clinical alert if applicable.

Data Analysis

The purpose of the data analysis is to determine the discriminative capacity and reliability of the proposed sensory system to identify postural deviations associated with scoliosis in school-aged children.

For this, quantitative metrics and standardized clinical criteria will be used to validate the results obtained from inertial signal processing.

The primary analysis measure is the Lateral Deviation Index [LDI], defined as the mean angular difference between the sensors placed at T3 and L2 during the forward bending Adams test. The LDI is expressed in degrees and represents the relative trunk inclination in the coronal plane.

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A clinical reference threshold of 5 degrees will be established, considered as a preliminary cutoff point for suspicion of scoliosis in visual screenings [Weinstein et al., 2008; Topalovic et al., 2020]. Participants with LDI ≥ 5° will be classified as "positive" for significant deviation, while values below will be considered "negative".

Clinical Validation

As the ground truth reference criterion, the professional visual evaluation performed by doctors and physiotherapists at the CRI Apizaco will be used, applying the Adams test and observing trunk asymmetries.

In cases where clinical history or previous radiographs are available, the Cobb angle will also be considered as a confirmatory parameter. Figure 7.

Box 7

Figure 7

Reference criterion by radiological test

Source Own elaboration

Based on clinical comparisons, the following performance metrics of the system are determined:

- Recall: proportion of cases with deviation correctly identified.
- Specificity: proportion of normal cases correctly classified.
- Accuracy: proportion of correct classifications over the total.
- Positive Predictive Value [PPV] and Negative Predictive Value [NPV].

These metrics will help determine the effectiveness of the system as an initial screening tool, as well as its potential clinical usefulness for use in school campaigns.

Results

With the development of this project, an intuitive and functional visual interface was successfully created, allowing real-time display of the inclination angle recorded by the accelerometers placed on the patients' backs.

This tool facilitates immediate observation of the measurements during the evaluation, enhancing the user experience and enabling quick decision-making based on reliable and up-to-date data. Figure 8.

Box 8

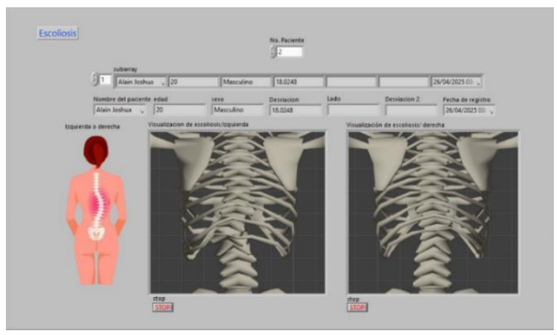

Figure 8

Visual Interface for Scoliosis Detection and Recording

Source Own elaboration

The system incorporated the creation and management of virtual records for each patient, enabling an organized and systematic follow-up of clinical progress.

This centralized digital database facilitates historical consultation of records, optimizes information management, and provides effective support for continuous monitoring of scoliosis progression or changes over time. Figure 9.

Box 9

Child Postural Evaluation Center - CRI Apizaco
Electronic Clinical Record | Scoliosis Assessment

Patient Name:	[redacted]	Age:	12 years
Evaluation Date:	08/06/2025	Handedness:	

Weight (kg):	26.7	Height (m):	1.38
BMI:	14.0	Medical History:	

Measured Inclination Angle	12.76°
Clinical Observations:	Mild curvature. Monitoring recommended.
Recommendations:	

Responsible evaluator: _____
Name and signature

Figure 9

Basic Virtual Record for Patient Follow-Up

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The clinical validation of the system was carried out through the comparison of the data obtained with radiological records and specialized professional evaluations. The results showed a high correlation and consistency between the device measurements and established clinical criteria, confirming the system's accuracy and reliability. This validation supports the use of the device as an effective complementary tool for the detection and monitoring of scoliosis in clinical settings.

This evaluation involved 25 children aged 8 to 12, with clinical assessments performed by specialists from CRI Apizaco using the Adams Forward Bend Test. Approximately 10% of the participants were diagnosed with scoliosis. The automated detection system misclassified only 3 cases.

The analysis focused on computing the recall of the system, reflecting its ability to correctly identify children with scoliosis. A confusion matrix was generated to visualize the system's performance. The results support the system's potential as a reliable screening tool in clinical settings. Figure 10.

Box 10

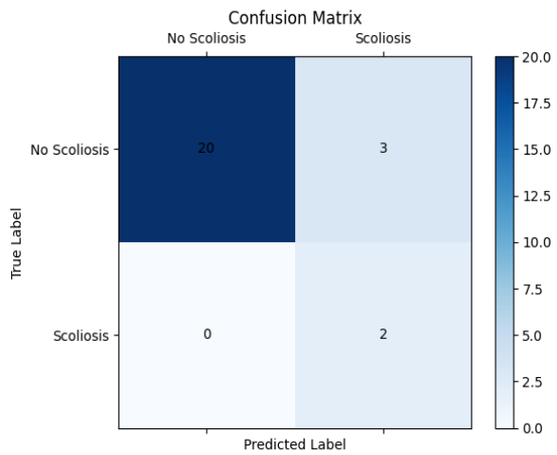

Figure 10

Confusion matrix used to evaluate system recall

To evaluate the clinical reliability of a scoliosis detection system, it is essential to measure not only how often the system is correct accuracy, but also how well it identifies true cases sensitivity and correctly excludes non-cases specificity. Figure 11.

Box 11

System Performance Metrics

Metric	Value
Recall	1.0
Specificity	0.8695652173913043
Accuracy	0.88
PPV	0.4
NPV	1.0

Figure 11

System performance Metrics

Conclusions

This project presented the design, implementation, and validation of a wireless sensor system based on inertial measurement units [IMUs] and ESP32 microcontrollers for the early detection of scoliosis in school-age children.

The developed architecture enables real-time data capture, Wi-Fi transmission, and automated recording through a graphical interface, facilitating objective, non-invasive, real-time monitoring of postural alignment.

Results obtained from real clinical data showed favorable system performance, validated through metrics including sensitivity, specificity, precision, positive predictive value, and negative predictive value, confirming its ability to discriminate between subjects with and without significant lateral deviation.

This demonstrates the system's potential as a complementary tool for clinical scoliosis screening, with advantages such as portability, low cost, and ease of implementation, suitable for school and community settings.

From an engineering perspective, the stability of wireless transmission, the effectiveness of filtering algorithms, and ergonomic design ensuring reproducible measurements were validated. However, to consolidate its effectiveness and expand its applicability, further testing with larger and more diverse communities, as well as validation in clinical populations, is necessary.

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Future work includes integrating machine learning algorithms for improved automatic classification, as well as developing cross-platform mobile versions to facilitate field use. Overall, this system represents a significant contribution to sensor-assisted diagnostic solutions, demonstrating the value of engineering in addressing public health challenges such as the early detection of scoliosis and improving timely patient care.

Declarations

Conflict of interest

The authors declare no conflicts of interest.

Author contribution

Sánchez-Cuapio, Iván Jesús: Contributed to the project idea, conceptualization, methodology, software, validation, resources, data curation and writing—original draft preparation.

Vázquez-Carrasco, Yenni: Contributed to the project idea, conceptualization, methodology, software, validation, resources, data curation, writing—original draft preparation, supervision and project administration.

Conde-Camacho, Julián: Methodology, validation, resources, writing—original draft preparation and visualization.

Gutierrez-Atecpanecatl, Jonathan: Conceptualization, validation, investigation, data curation and visualization.

Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

As the data involve sensitive information related to minors, access is restricted to protect participant confidentiality, in accordance with the ethical guidelines of the Centro de Rehabilitación Integral [CRI] Apizaco.

The algorithms, hardware schematics, and software developed for the sensory system may be shared for academic or research purposes upon formal request.

Abbreviations

AUC	Area Under the Curve
ESP32	Espressif Systems Protocol 32-bit Microcontroller
GUI	Graphical User Interface
IDL	Index of Lateral Deviation
IMU	Inertial Measurement Unit
MPU6050	Motion Processing Unit [IMU with gyro + accel.]
PC	Personal Computer
RF	Random Forest
ROC	Receiver Operating Characteristic
T3	Thoracic Vertebra 3
L2	Lumbar Vertebra 2
Wi-Fi	Wireless Fidelity
ANN	Artificial Neural Network

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Article

Application of Information Technology in the improvement of administrative processes: Web-based system for activating and monitoring surveys

Aplicación de la Tecnología de la Información en la mejora de procesos administrativos: Sistema Web para la activación y control de encuestas

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Abstract

Currently, websites play a fundamental role in data collection and information access. An online presence has become a key factor in the success of projects, organizations, and businesses. A well-designed website enables efficient interaction between users and systems, facilitating the execution of processes in an organized and secure manner. To develop effective web solutions, it is essential to analyze users' specific needs and define technological tools that meet those requirements. In this context, the present project focuses on the development of a web-based survey management system aimed at replacing traditional methods or generic forms. The platform has been designed based on principles of usability, accessibility, security, and efficiency, in order to enhance user experience and ensure the integrity of the collected information.

Objectives	Methodology	Contribution
Develop a website for survey management that replaces traditional methods	This project falls within the scope of applied research, as it seeks to address a specific problem related to survey management through the implementation of a website.	Development of a specialized website for survey management, which contributes to: • Technology: development of a proprietary platform. • Practical impact: improves information management. • Institutional benefit: modernizes internal processes

Website, User, Methods

Resumen

En la actualidad, los sitios web desempeñan un papel fundamental en la recolección de datos y acceso a la información. La presencia en línea se ha convertido en un elemento esencial para el éxito de proyectos, organizaciones y negocios, un sitio web bien diseñado permite una interacción eficiente entre el usuario y el sistema, facilitando la ejecución de procesos de forma ordenada y segura. Para desarrollar soluciones web efectivas, es indispensable analizar las necesidades específicas de los usuarios y definir herramientas tecnológicas que respondan a dichos requerimientos. En este contexto, el presente proyecto se enfoca en el desarrollo de un sitio web orientado a la gestión de encuestas, con el propósito de sustituir métodos tradicionales o formularios genéricos. La plataforma ha sido diseñada bajo criterios de usabilidad, accesibilidad, seguridad y eficiencia, con el fin de optimizar la experiencia del usuario y garantizar la integridad de la información generada.

Objetivos	Metodología	Contribución
Desarrollar un sitio web para la gestión de encuestas que sustituya los métodos tradicionales	Este proyecto se enmarca dentro de una investigación aplicada, ya que busca resolver una problemática concreta relacionada con la gestión de encuestas mediante la implementación de un sitio web.	Desarrollo de un sitio web especializado en la gestión de encuestas. lo cual contribuye a: • Tecnología: desarrollo de plataforma propia. • Practica: mejora la gestión de la información • Institucional: moderniza los procesos internos.

Sitio Web, Usuario, Métodos

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

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Introduction

Nowadays, websites play a fundamental role in collecting data and obtaining information in real time, as they play an essential role in today's digital age, where online presence is a key component for the success of any project, organisation or business.

A well-defined website allows for adequate interaction between the user and access to system processes, so developing an effective website involves a series of steps ranging from conceptualisation and design to implementation and optimisation of functionalities.

Web applications facilitate the exchange of information between participants, accelerate decision-making and are therefore a relevant and important task, the quality of which is continuously improving.

For the development of web projects, it is necessary to carry out a needs analysis to identify the appropriate tool to execute processes efficiently and meet user requirements.

Currently, the Instituto Tecnológico Superior de Irapuato [ITESI], in the Computer Systems Engineering degree programme, does not have a system that facilitates the comprehensive management of surveys, a fundamental tool for obtaining valuable information from the community in relation to quality processes, administrative procedures and other relevant areas.

Thus, this project focuses on the creation of a website that meets the specific needs of users, ranging from the initial planning of survey processes to their implementation. To this end, key elements such as usability, accessibility and user experience are taken into account, as well as technical aspects related to service optimisation and information security, which will enable data to be collected efficiently within a unified system.

Therefore, the project aims to implement a survey system for a higher education institution, given that this process allows institutions to collect opinions, assess specific needs and analyse trends efficiently, seeking not only to optimise the experience during the application of surveys, but also to generate specific reports and secure the information generated, which is key to quality processes.

Theoretical Framework

As part of the theoretical framework, the aim is to provide a theoretical basis for the key concepts, as well as to offer an analysis of previous studies that will serve as a basis for the development of the research, for which the following concepts are used:

Net Framework

The .NET Framework is a managed execution environment that provides a variety of services to your running applications. It consists of two main components: the Common Language Runtime [CLR], which is the execution engine that handles running applications; and the .NET Framework Class Library, which provides a library of tested and reusable code that developers can use in their own applications. [Sinha, 2015]

The use of .Net Framework allows for the management of application execution and provides services such as memory and security management, facilitating interoperability between different programming languages, which allows developers to build high-performance applications for various environments. A study by Souza & Raniery [2019] analyses the impact of the .NET Framework on application development, highlighting its ability to improve developer productivity by integrating multiple programming languages into a single environment.

Web API 2

This is a framework that is part of ASP .NET, designed to facilitate the creation of HTTP services. It facilitates communication between applications, as well as offering support for features such as routing, serialisation and action controllers, allowing developers to create scalable, high-performance applications for modern web environments. [Esposito, 2014]

SQL Server 2019

This is a Relational Database Management System [RDBMS], where applications and tools connect to an instance or SQL Server database and communicate using T-SQL. [Microsoft Ignite, 2021] SQL stands out for its capacity and security and is widely used for applications that can handle large volumes of data.

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JavaScript

JavaScript is a programming language that developers use to make interactive web pages. JavaScript functions can improve the user experience on a website, and as a server-side scripting language, it is one of the main technologies of the World Wide Web. [AWS, 2024]

JSON

JavaScript Object Notation is a text-based format for storing and exchanging data in a way that is human-readable and machine-parseable. It allows data to be transferred between a server and a web application and is frequently used because it simplifies the exchange of data between different technologies, facilitating fast, dynamic, and interactive web experiences. [Oracle, 2024]

HTML.

HyperText Markup Language is a programming language that, unlike other languages, is not composed of instructions, but rather a set of tags that organise and declare the purpose of each piece of content in the document. In this sense, HTML is text written with a particular syntax that the browser is able to read and apply. [Gauchat, 2013]

Bootstrap

It is a set of frontend tools used to create complete web pages, i.e. it has a set of ready-to-use components, thus prioritising the user experience. [Yoris, 2023]

CSS

This is an abbreviation for Cascading Style Sheet, whose purpose is to define how HTML elements are to be displayed and in what style they are to be presented. Styles are normally stored in style sheets and added to the HTML coding. [García, 2007]

Jquery

This is free and open-source software with a design that facilitates navigation within a document, providing web application developers with add-ons that streamline project development. [Parada, 2019]

Advantages of use

Web technologies are essential for the development of applications accessible through browsers. These technologies cover various areas and protocols that enable a better online experience.

One of their main advantages is the possibility of global, real-time access, achieving collaboration and connectivity between users. The following advantages of the tools used in this project are described below [see Table 1].

Box 1

Table 1

Table of advantages of JQuery and Bootstrap

JQuery		
Appearance	**Advantage**	**Disadvantage**
Ease of use	Simplifies simulation and event management	May be excessive for small projects
Compatibility	Offers solutions for compatibility problems	New browser versions reduce the possibility of using it.
Size	Reduces the code needed for functions e.g. animations	Adds weight to the code by including libraries for its use
Updates	It is stable and reliable for projects, with a large number of plugins and a large community for support.	Its popularity is beginning to be displaced by other tools.
Bootstrap		
Responsive Design	It offers a system that facilitates the development of responsive designs.	Can be limiting in the face of more customised designs
Components	Provides reusable components	The site can look generic if it is not properly customised.
Development	Speeds up initial development by offering predefined classes and styles	May lead to heavier projects due to unused predefined styles
Compatibility	Compatible with most browsers	Older functions may be incompatible with modern tools and approaches.

Methodology

This project is part of applied research, as it seeks to solve a specific problem related to the management of surveys through the implementation of a website.

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Therefore, a technological solution is proposed to optimise data collection processes, prioritising criteria of usability, accessibility, security and efficiency through the cascade life cycle [see Figure 1].

This cycle was chosen because the proposed system has clearly defined requirements from the initial stage, which allows progress to be made in a structured way through sequential phases. This approach facilitates the detailed documentation of each stage, the control of the project and an orderly implementation, characteristics that are especially relevant in an institutional environment where the aim is to guarantee quality, traceability and compliance with the established objective.

Box 2

Figure 1

Cascading life cycle

Source: Own elaboration

Results

The implementation of a website that allows administrative procedures to be carried out represents a significant advance in terms of the optimisation of processes carried out in the traditional way, as it allows data collection, management and processing to be carried out in an agile and efficient manner. The functionality of the project is shown below.

In Figure 2, you can see on the left side the access to the website, where it is necessary to have a previous registration within the system to securely access the site, once inside the system you can see the options menu which is shown in Figure 3, in this you can have access to different options of the system such as survey configuration, questionnaire assignment, form programming, and the results of the evaluations.

Box 3

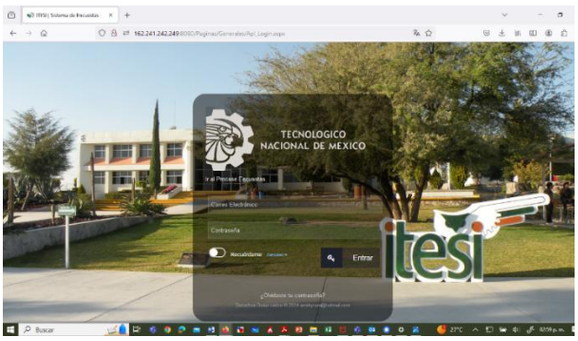

Figure 2

Home screen

Box 4

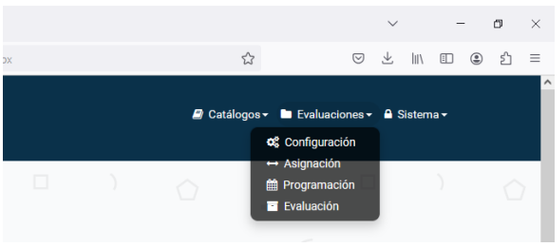

Figure 3

Source: Own elaboration

Figure 4 shows the list of questionnaires available for response, which were previously configured from the site's Configuration menu, allowing the administrator to define the content, validity and recipients of each survey.

Each item in the list includes the name of the questionnaire, its status [available or unavailable] and a visual indicator that indicates whether the user has already responded to the survey, which facilitates the monitoring of progress and compliance by the participants.

Box 5

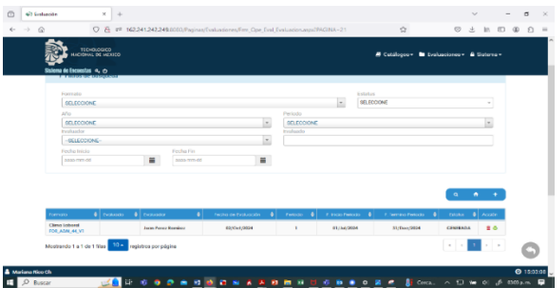

Figure 4

Survey information available

Once the user has completed the survey, the system generates a report in PDF format that presents the responses recorded in a structured and clear manner.

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As shown in Figure 5, this report includes general data of the participant, such as gender, area, position and date of application, followed by the display of the survey sections with their respective questions, accompanied by the selected response options.

The format facilitates the individual review of the results, allowing the identification of trends, perceptions or areas for improvement from a personal or group perspective, depending on the objective of the analysis. This type of report is useful for decision-making and monitoring indicators in institutional processes such as exit surveys.

Box 6

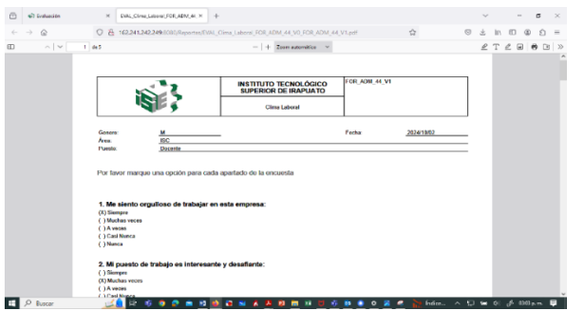

Figure 5

Survey information available

Source: Own elaboration

Figure 6 shows the Assessment Scheduling section, where you can manage and configure the different survey formats available in the system. This screen allows you to filter assessments by year and status, making it easier to search for specific records using the drop-down fields and the "Search" button. Below the filter, a list of previously configured survey formats is displayed, identified by their key and name.

Box 7

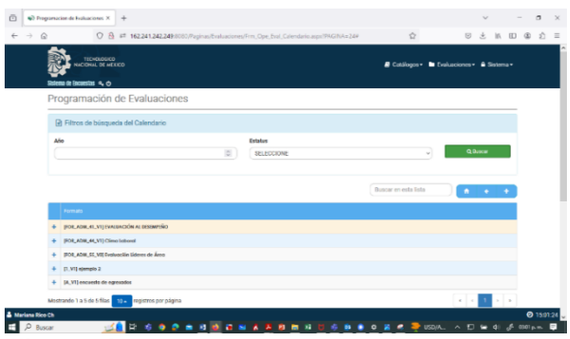

Figure 6

Evaluation scheduling

Source: Own elaboration

Figure 7 shows the Assessments section of the system, which provides the user with two main functions represented by visual and intuitive buttons. The first option, View, allows access to the results of previously administered assessments.

When selected, the system displays the generated reports, either individually or in a consolidated format, depending on the survey type and configuration. This feature is useful for reviewing performance, identifying patterns, or performing comparative analysis.

The second option, Evaluate, directs the user to the module where they can respond to or apply a new assessment. This section is designed to facilitate interaction with the digital forms, guiding the user through the different sections of the survey. Both functions are clearly defined and presented visually with icons that reinforce their purpose, contributing to simple and efficient navigation within the system.

Box 8

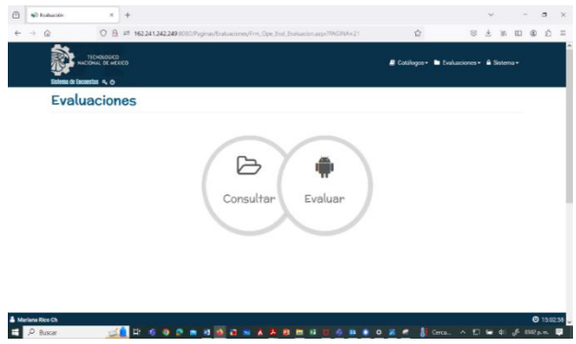

Figure 7

Evaluations and Consultations

Source: Own elaboration

Conclusion

The creation of this website has evolved significantly, becoming an accessible and efficient process thanks to modern tools and innovative approaches. so websites are now proving to be an effective tool, as they allow administrative processes to be carried out efficiently.

Their intuitive design and customisable features enable users to easily create, distribute and analyse surveys, simplifying the analysis process and allowing information to be viewed in real time. However, it is crucial to maintain a balance between ease of creation and the technical quality of the site, with aspects such as security and user experience being a priority.

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This is how websites have become a powerful tool that allows access to the digital world, contributing to the development of increasingly efficient environments.

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Declaration

Conflict of interest

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

Contribution of the authors

Rico-Chagollán, Mariana: I contributed to the project idea, development, research and editing.

Rodríguez-Campos, Juan Carlos: I contributed to the development of the project.

Chacon-Olivares, Maria del Carmen: Contributed to the development of the project.

Availability of data and materials

For more information on the availability of data or programming methodology during this study, please contact the author.

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Abbreviations

CSS	Cascading Style Sheets
HTML	Hypertext Markup Language
ITESI	Tecnológico Superior de Irapuato
MySQL	My Structured Query Language
PHP	Hypertext Preprocessor
TecNM	Tecnológico Nacional de México

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Background

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Article

Development of a document management system in accordance with ISO 9001:2015 for the coordination of comprehensive transportation in Irapuato

Desarrollo de un sistema de gestión documental conforme la ISO 9001:2015 para la coordinación del transporte integral en Irapuato

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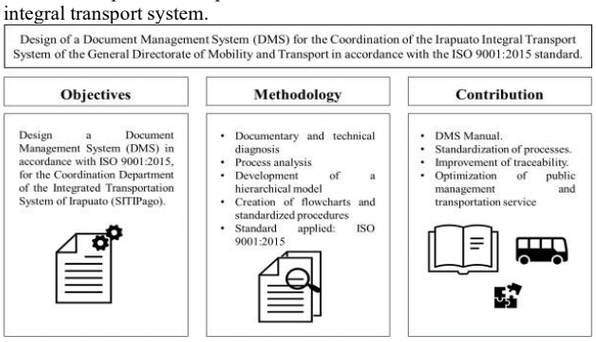
Abstract

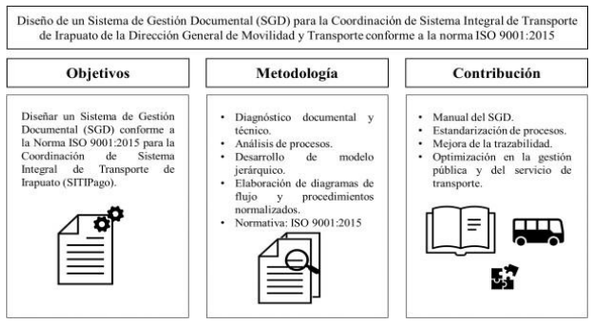
This project proposes the design of a Document Management System [DMS] in accordance with the ISO 9001:2015 Standard, applied to the Coordination of the Integral Transport System of Irapuato [SITIPago]. It arises as a response to deficiencies in the issuance, documentary control of prepaid cards, which mainly affect students. From a documentary and technical diagnosis, the absence of standardized procedures and traceability was evidenced. A hierarchical model of documents was developed, with conservation policies, control formats, instructions, and continuous improvement tools. In addition, flowcharts and standard operating procedures were designed to facilitate capacity and standardization. The result is the development of an SGD Manual, aimed at future implementation. In which it is demonstrated that by applying international standards, public management and quality of service in Irapuato are improved in the issue of the coordination of the integral transport system.



Document management, Standardization, Public management

Resumen

Este proyecto propone el diseño de un Sistema de Gestión Documental [SGD] conforme a la Norma ISO 9001:2015, aplicado a la Coordinación de Sistema Integral de Transporte de Irapuato [SITIPago]. Surge como respuesta a deficiencias en la emisión, control documental de las tarjetas de prepago, que afectan principalmente a estudiantes. A partir de un diagnóstico documental y técnico, se evidenció la ausencia de procedimientos estandarizados y trazabilidad. Se desarrolló un modelo jerárquico de documentos, con políticas de conservación formatos de control, instructivos, y herramientas de mejora continua. Además, se diseñaron diagramas de flujo y procedimientos normalizados para facilitar la capacidad y estandarización. El resultado es la elaboración de un Manual del SGD, orientado a una futura implementación. En el que se demuestre que al aplicar normas internacionales se mejora la gestión pública y calidad del servicio en Irapuato en el tema de la coordinación del sistema integral de transpor1te.



Gestión documental, Estandarización, Gestión pública

Area: Advocacy and attention to national problems

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Introduction

In the last few years, prepaid systems for public transportation have become popular in different cities in Mexico as part of efforts to modernize urban mobility. In Irapuato, Guanajuato, the Irapuato Integrated Transportation System has implemented the Prepaid and Credentialing System [SITIPago], managed by the Irapuato Integrated Transportation System Coordination Office in the General Directorate of Mobility and Transportation in collaboration with concessionaires and the company NRTec, which is responsible for manufacturing the cards issued by the coordination office, installing recharge points, and monitoring cash flows.

This system represents a significant step toward more efficient transportation; however, it faces operational and documentary challenges that affect its performance, especially for the student community, one of the largest and most frequent users of the service, representing a significant portion of the population of 145,308 students according to INEGI, 2020.

The importance of optimizing SITIPago lies in its direct impact on users' quality of life, by facilitating access to public transport and ensuring a reliable and equitable service. The added value of this research lies in the proposal of a Document Management System [DMS] based on Microsoft SharePoint and aligned with the ISO 9001:2015 standard, as opposed to manual systems or non-standardized platforms that predominate in similar contexts. As observed in the current system, it lacks traceability and control, which is why the proposed DMS aims to achieve:

1. A hierarchical structure that organizes documents logically.
2. Standardized workflows that streamline key processes such as card issuance and complaint management.
3. Control formats that ensure consistency and traceability.
4. Regulatory compliance with international and local standards.
5. An SGD Manual that serves as a practical guide for implementation.

These features enable more efficient, transparent, and scalable document management.overcoming the limitations of the current system to be migrated.

The main problem addressed by this research is the lack of standardization and traceability in the document management of the Irapuato Integrated Transport System Coordination managed by SITIPago, which generates inefficiencies in processes such as card issuance and reactivation, as well as in the reception and resolution of complaints.

These deficiencies mainly affect students, who depend on preferential fares, but they also impact other sectors such as the elderly, people with disabilities, and in general the 71,000 users who use public transportation in the municipality of Irapuato [Garduño, F., 2024].

The research question asks whether the design of an SGD aligned with ISO 9001:2015, supported by industrial engineering tools, will optimize internal coordination processes, improve the user experience, and ensure regulatory compliance, fostering an organizational culture of continuous improvement.

Methodology

For the development of the research project, an analysis was carried out on the regulations applicable to document management and information control, without neglecting the perception of the end customer, in this case, public transport users in Irapuato. According to the International Organization for Standardization [2015], “documented information must be controlled to ensure that it is available and suitable for use when and where it is needed.” That is why we propose the development of a document management system for the Coordination of the Integrated Transport System in Irapuato, Guanajuato, based on the ISO 9001:2015 standard and supported by industrial engineering methodologies. To develop this project, different tools and methodologies are incorporated that allow for the schematization, examination, and optimization of document management processes in coordination. Among the most notable tools are the following:

Flowcharts and UML

A flowchart is a graphical representation that illustrates the flow of an algorithm or a sequence of routine actions using specific symbols connected by arrows, which indicate the order of operations.

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In the field of administration and organizational management, both in the public and private sectors, it is used to show the stages or steps of a process, the logical sequence in which they are carried out, and the interactions between those responsible for executing them. [Ministry of National Planning and Economic Policy, 2009].

Flowcharts and UML [Unified Modeling Language] activity diagrams were used to describe processes as workflows through sequential, concurrent, and branched actions to support the credentialing and complaint management processes in the SITI payment system.

These tools allow the flow of decisions, tasks, and roles to be visualized, facilitating the detection of critical points and inefficiencies in the system.

Process map

A process map is a graphical representation that illustrates the interactions and flows within an organization's processes in a structured way.

According to [Plazas, 2017], its purpose is to observe the sequence and integration of all processes, emphasizing that they should not focus solely on a specific area, but rather on how the company's functions interrelate to meet strategic objectives and satisfy the customer. This type of tool allows organizations to clearly visualize how activities are connected, from management processes to operational and support processes, facilitating the identification of areas for improvement.

Process maps contribute to document management planning. These types of maps represent a group of tasks that allow for the proper control and organization of documentation, from its receipt to its final disposal. To create the DMS manual, strategic processes were broken down and the general planning of the document system was established. At this point, the policies and guidelines that encompass the DMS are broken down. It also includes the audit program and continuous improvement.Operational processes cover the main actions of the document lifecycle, whether physical or digital. These documents are classified to retain important information and eliminate obsolete information.

Once stored, they are made available for access and consultation, allowing SGD users to obtain information quickly and securely. Throughout their useful life, documents are subject to preservation, but when they are no longer needed, they can be disposed of in a controlled manner or transferred to historical archives. Support processes involve training staff so that those involved in the SGD are familiar with the regulations and the use of tools to ensure proper implementation. Technical support for the system is also considered, which includes updating the SGD and protecting sensitive information by restricting access to unauthorized personnel.

By mapping these processes, optimized, secure document management is guaranteed, aligned with the objectives of the organizations, so that all processes are recorded, transparent, and preserve institutional information appropriately.

SIPOC diagram

The SIPOC diagram is a graphical representation of a management process that includes Suppliers, Inputs, Process, Outputs, and Customers, and is particularly useful for mapping processes at different levels of detail [Parkash and Kaushick, 2011] and [González and Escobar, 2021]. Indeed, this tool is particularly useful in public institutional environments, where document traceability and proper information management are key elements for efficient administration.

Microsoft SharePoint

Microsoft SharePoint is a web platform that can be used as a secure place to store, organize, and share information from any device, as well as access it. All you need is a web browser, such as Microsoft Edge, Chrome, or Firefox, which works in conjunction with tools such as Word, Excel, Teams, and Copilot, according to Microsoft.com, 2025. Therefore, SharePoint facilitates content management, intranet portal creation, and internal communication, optimizing workflows and increasing productivity. According to Microsoft, it is a platform that offers granular permission settings, meaning it has the ability to define specific access permissions for users or groups that make up the system, allowing administrators to control access at the site, list, and item level.

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Google Drive

Google Drive is a cloud storage service developed by Google that allows users to securely store files and documents such as text files, spreadsheets, presentations, images, and videos on remote servers, according to Piensasolution.com, 2025.

Results

A diagnosis was carried out, which made it possible to identify the problems causing dissatisfaction among SITIPago users in terms of coordination, mainly related to a non-existent document management system, as well as other problems that need a short-term solution. We identified these using a cause-and-effect diagram or Ishikawa diagram, which in this work sets out the causes and sub-causes of the problem.

Box 1

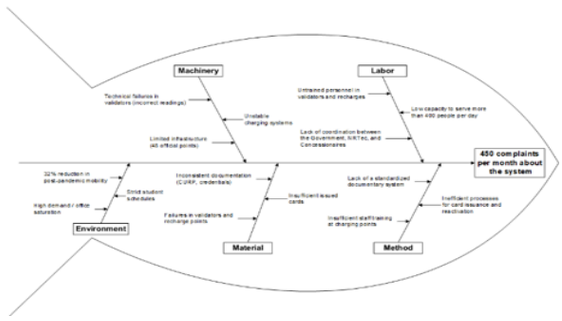

Figure 1

Cause and Effect Diagram: Inefficiency in the Document and Operational Management of the SITIPago System

The main causes of this problem: Non-existent document management system. Although there is document management in place at the Irapuato Transport System Coordination Office, there is no system for controlling and reviewing the documents generated during its daily operations, which complicates and hinders administrative and operational processes. Considering that the Prepayment and Credentialing System is relatively new in its operation [in the last four years] since the coordination focused on the mass issuance of the prepayment card. [Government of Irapuato, 2023].

- Limited technological infrastructure. The lack of adequate technological tools and systems hinders the efficient management of documents and operational processes, affecting the speed and accuracy of daily operations.
- Lack of training. Staff do not have sufficient training to effectively manage the system's processes and tools, which contributes to errors and delays in management.
- Inefficient operational design. Current operational processes are neither optimized nor standardized, creating bottlenecks, service saturation [such as long lines at offices], and a high number of complaints, with 450 complaints reported monthly. [Venegas, N., 2024]

According to field research, it was observed that this generates dissatisfaction among students, as there are numerous complaints about the lack of access to the benefits of the preferential card due to documentary and operational inefficiencies. Figure 2 shows the number of students enrolled at ITESI's Irapuato campus as an example of this situation.

Box 2

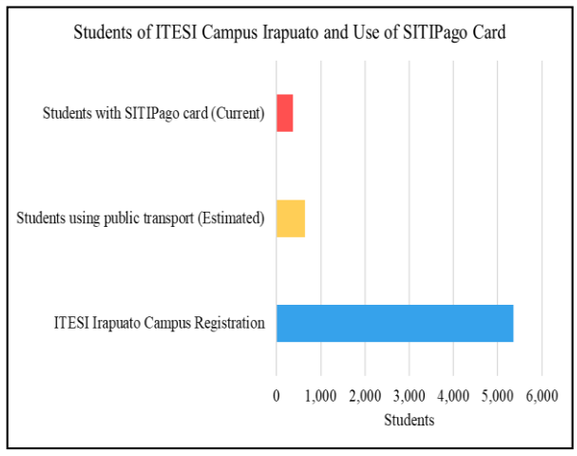

Figure 2

ITESI Campus Irapuato Registration and Use of SITIPago Card

Following this analysis and using the methodology selected for the design of the document management system, the following phases were developed:

Phase 1: Document management system for the Coordination of the Irapuato Integrated Transport System

During this phase, the current situation and document requirements are assessed by carrying out the following activities:

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1.1 Compilation of existing information [Review of regulations and regulatory framework]:

It consisted first of reviewing local and institutional regulations such as the federal archives law, the federal law on the protection of information held by private individuals, the general law on transparency and access to information, and the regulations of the Irapuato, Guanajuato, mobility and transportation department to identify the documentary scope of the Irapuato comprehensive transportation system coordination and the minimum obligations that must be met in terms of documentary control and monitoring.

Highlighting Article 6 of the mobility and transportation regulations, which establishes the existence of a database as a tool for storing, controlling, and monitoring all information related to transportation [Mobility and Transportation Regulations of the Municipality of Irapuato, Guanajuato, 2021].

1.2 Survey the population and analyze the results:

A survey was conducted among 387 users of the SITIPago system to ascertain their actual perceptions of the problems they encounter with the processing, recharging, and use of cards. The results revealed numerical data and various opinions of dissatisfaction with the system's operational failures due to the lack of defined procedures.

Figure 3 below shows the percentage of users who would recommend the use of the SITIPago card. It shows that only 55% of users are satisfied with the card, as approximately 45% of users are unlikely to recommend it, suggesting that a significant proportion of users are not fully satisfied.

Box 3

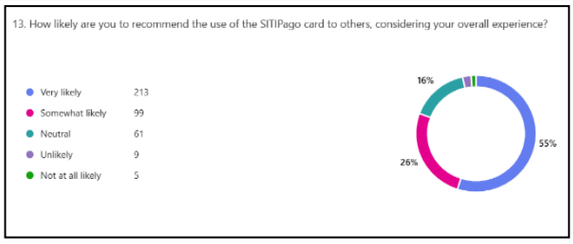

Figure 3

Percentage of users who would recommend using the SITIPago card

1.3 Development of a checklist based on ISO9001:2015:

To evaluate the status of the document management system for the coordination of the comprehensive transportation system in Irapuato, a checklist was developed based on section 7.5 of ISO 9001:2015, which helped identify whether the basic elements of a document management system were present.

1.4 Analysis of current document processes:

In turn, tools such as flowcharts and SIPOC diagrams were used to identify inputs, outputs, key processes, and actors related to information management in order to better understand the processes, using the mobility and transportation regulations of the municipality of Irapuato, Guanajuato, as a reference.

The construction of the SIPOC diagram and the flowchart of the database are shown below.

Box 4

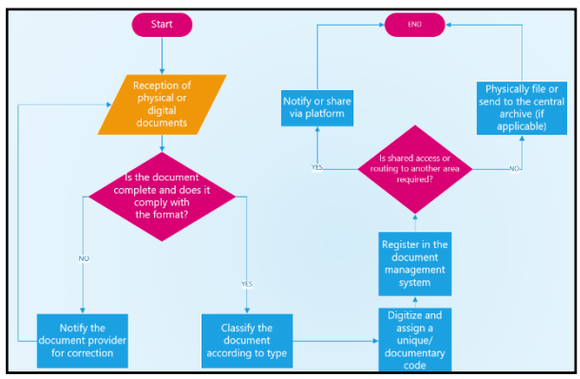

Figure 4

Database flowchart

Box 5

Process: Database of the General Directorate of Mobility and Transport | Date: 07/05/2025
Prepared for: Emilio Cabello Jaime

DIAGRAM SIPOC

S (Supplier)	I (Inputs)	P (Process)	O (Outputs)	C (Customers)
Inspectors	Reports	Document Reception	Organized documents	Dirección general
Dealers	Proceedings	Document review	Digital database	Inspectors
Traffic police	Trades	Classification and validation	Electronic backup	Administrative units
Private companies (NRTec)	Files	Registration and digitization	Accessible history	Citizenship (when applicable)
Ciudadanía	SITIPago card issuance/replacement requests	Indexing		
	Physical formats	Safeguarding and control		
	Digital formats			

Figure 5

Diagram SIPOC

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1.5 Theoretical identification of gaps with the Data Bank:

Thanks to the information gathered in Activity 1 and with the help of the checklist, significant gaps were identified between the provisions of the mobility and transport regulations of the municipality of Irapuato, Guanajuato, and international requirements applicable to each department of the Secretariat of Mobility and Transport, including the coordination of the Irapuato integrated transport system. such as the lack of policies for archiving or identifying documents, the absence of an established format, and the lack of measures to protect information from loss, damage, or misuse

Box 6

	GENERAL DIRECTORATE OF MOBILITY AND TRANSPORT	Code	DMGT-CSITI-FR-01
IRAPUATO		Version	1.0
	DOCUMENT COMPLIANCE CHECKLIST FORMAT BASED ON ISO 9001:2015 IN THE INTEGRATED TRANSPORT SYSTEM COORDINATION OF IRAPUATO	Date	05-30-2025
		Page	1 de 1

PERSON IN CHARGE OF COMPLETING AND VERIFYING THE LIST	
Name	Cabello Jaime Emilio, Campos Guevara Maria Daniela, Crisanto López Mariana Guadalupe, Linares Ramirez Karla Angélica
Position	External

DESCRIPTION OF THE CRITERION	YES	NO	OBSERVATIONS
The information is available and is suitable for use when needed		x	Partially Inferred Gap: It is understood that management is responsible, but the availability or relevance of the information when required is not guaranteed.
The information is protected against loss of confidentiality, misuse, or loss of integrity.		x	There is no mention of security mechanisms, backups, or access controls. Gap: It is not mentioned how information is protected against damage, loss, or misuse.
Every document is identified with title, date, author, etc.		x	The regulations mention the Database as a general instrument, but do not indicate how its internal elements are identified. Gap: Absence of formal criteria for document identification.
The appropriate format and access methods have been determined.		x	The regulations do not specify whether the database is physical, digital, or hybrid. Gap: Lack of definition of the document format and storage medium.
The documents are reviewed and approved by the competent authority.		x	Document validation or authorization by competent personnel is not mentioned. Gap: A formal workflow for document review and approval is not guaranteed.
Distribution, access, retrieval, use, storage, preservation, change control, and final disposal are controlled.		x	The regulations do not include version control mechanisms or a change history. Gap: There is no traceability of modifications or version control.
External access is controlled (if applicable), ensuring confidentiality.		x	It is inferred that access is managed by the General Directorate, but the process and authorization levels are not detailed, and retention periods, document disposal, and citizen or institutional access are not addressed. Gap: There are no policies on document preservation, archiving, or identification.

Prepared by:	Reviewed by:	Approved by:
(Name) Position: Date:	(Name) Position: Date:	(Name) Position: Date:
CHANGE CONTROL		
DATE:	VERSION	REQUEST

Figure 6

Document compliance checklist and existing gaps in the database

1.6 Preparation of the diagnostic report:

A diagnostic report was developed that compiles and summarizes the findings obtained in the previous activities. The main findings are as follows:

- Disorganization and lack of document standardization
- Absence of formal control over versions, access, and responsible parties
- Lack of clarity regarding document preservation and final disposal
- Negative user perception of the SITIPago system.

1.7 Review and adjustment of the diagnosis

After preparing the initial diagnostic report, I proceed to review and adjust it to ensure that the information is consistent, accurate, and useful for the next phase of the project.

Phase 2: Structuring the document management system based on ISO 9001:2015

Continuing with the development of the next phase, the following activities were carried out:

2.1. Definition of the SGD structure:

The activity consisted of designing a hierarchical and structured system to classify the documents in the document management system for the Irapuato integrated transport system coordination area in accordance with Article 7.5 of the ISO9001:2015 standard.

In order to define the various types of existing documents, understand their grouping, and identify those responsible for their preparation, review, and control, thus ensuring that documentation is orderly, accessible, traceable, and managed in an appropriate manner, the structure is as follows:

Box 7

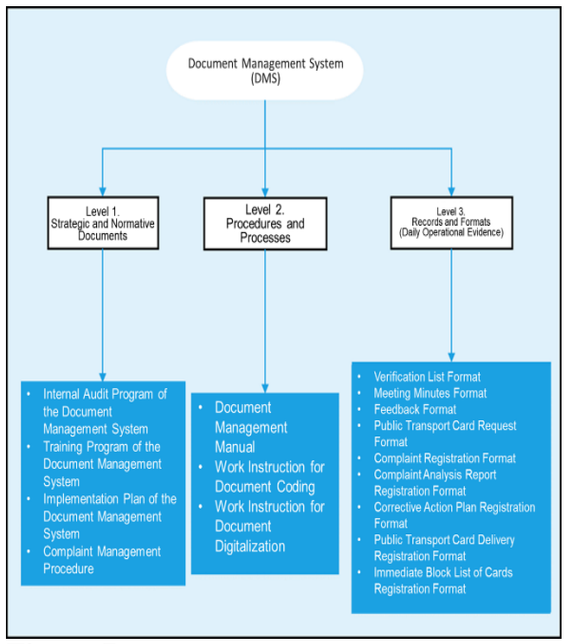

Figure 7

Hierarchical diagram of the proposed document structure

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2.2. Selection of digital tools for data storage:

Microsoft SharePoint is chosen as a viable option for digital storage due to the aforementioned features.

Below is the workspace of the Microsoft SharePoint digital tool.

Box 8

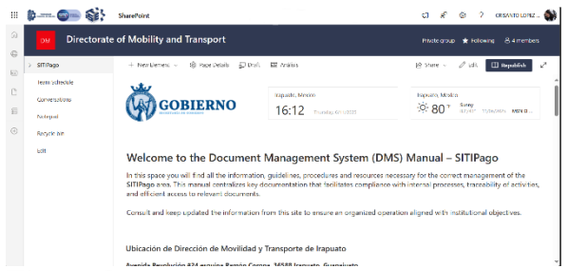

Figure 8

Microsoft SharePoint Workspace

Source: Own elaboration, obtained from: https://mspoweruser.com/wp-content/uploads/2016/05/SharePoint-home-page.png

2.3. Development of a document control matrix:

This tool ensured the systematic organization and tracking of all documents generated in the area for the coordination of the comprehensive transportation system in Irapuato, linking each document with its code, date of issue, responsible party, hierarchical level, and review status.

2.4. Definition of access, update, and version control policies:

Access, updating, and version control policies were designed to ensure that each document is available to those who need it, protected against unauthorized modifications, and updated based on operational or regulatory changes. The proposed policies based on ISO 9001:2015 are presented below.

Document policies

- Controlled access: Access to documents will be restricted according to the user's role. Only authorized personnel may modify or delete documents.
- Scheduled updates: Documents must be reviewed and, if applicable, updated at least once a year or when the process is modified.
- Version control: All updates must generate a new version documented with its respective change history, including version, date, and person responsible.
- Use of standard formats: All documentation must comply with the institutional format [logo, code, version, date, responsible party].
- Deactivation of obsolete versions: Once a new version is issued, the previous version will be archived as "obsolete" and withdrawn from operational use.
- Means of publication: Current documents will be available in authorized digital media [institutional Drive], with restricted access by area.

2.5. Proposed guidelines for document preservation and final disposal:

In turn, a proposal was designed to establish critical conservation objectives and final disposal of documents, such as secure storage, responsible disposal, and compliance with information retention periods.

Phase 3: Develop standardized procedures and workflow:

Likewise, the following activities were carried out during the final phase:

3.1. Development of operating procedures:

This activity consolidates a functional operational framework for the SGD, facilitating internal communication, timely access to information, and compliance with quality standards for document management in SITI coordination.

Box 9

Table 1

Description of the SITI complaint management procedure

STEP	ACTIVITY	RESPONSIBLE	DOCUMENT / ENTRY RECORD	DOCUMENT / CHECK-OUT
1	Verbal or written receipt of the complaint.	Recipient of complaint.	Verbal or written complaint.	Complaint registration form.
2	Data registration and sending to the corresponding area.	Recipient of complaint.	Complaint registration form.	Registration sent to the corresponding area.
3	Analysis of the complaint and validation of root cause.	Quality coordinator.	Record of complaints.	Complaint analysis report.
4	Proposal of solution and corrective action if applicable.	Quality coordinator.	Analysis report.	Corrective action plan.
5	Response communication to the user.	Recipient / Quality Coordinator.	Corrective action plan.	Closure communication to the user.
6	Closure of the case and archiving of the file.	Document Control Coordinator.	Closing communication.	Complete complaint file filed.

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Box 10

Table 2

Description of the SITI card management procedure

STEP	ACTIVITY	RESPONSIBLE	DOCUMENT/CHECK-IN	DOCUMENT/CHECK-OUT
1	Receipt of card application.	Applicant/SITI Coordination	-	Application record in database.
2	Delivery and validation of data and requirements of the applicant.	NRTec	Applicant's documents.	List of requirements with validated documents.
3	Approval by the Finance area.	NRTec	List of validated documents.	List of documents signed by the finance department.
4	Application and activation of the card with the SITIPago system provider.	NRTec	List of documents approved.	Confirmation email and photo taking.
5	Physical delivery to the user of the contract.	NRTec / Applicant	Card printing and activation.	SITIPago card delivery record in a database.
6	Digital or physical receipt of the procedure file.	Document control (Government/ Applicant/ NRTec)	Scanned user file to upload to the database.	Delivery of contract to the user.

3.2. Workflow diagram design:

It guarantees uniform and controlled management of document processes, reinforcing the traceability of information and promoting compliance with the guidelines established in the SDG structure and in the ISO 9001:2015 standard.

Box 11

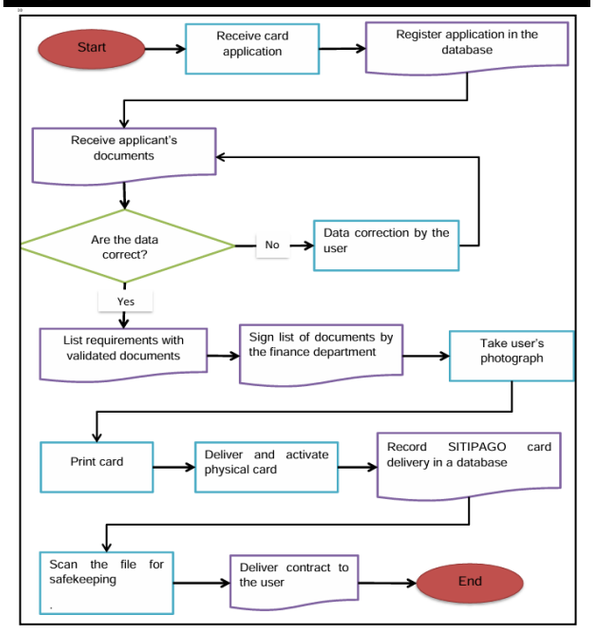

Figure 9

SITI Complaint Management Workflow Diagram

Box 12

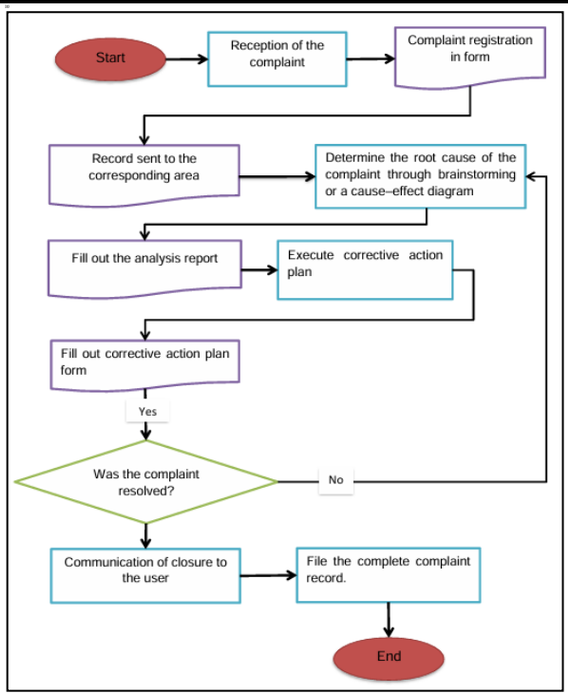

Figure 10

SITI card application management workflow diagram

3.3. Format for informational meetings:

The purpose of this activity is to provide clear, standardized templates for meeting notices, meeting minutes, and follow-up on agreements, ensuring the traceability of decisions made and promoting the participation of the operational team in the SGD.

3.4. Proposals for a gradual implementation plan:

Developing a gradual implementation plan ensures that the system implementation is feasible, understandable, and adaptable to current human and technological resources, while allowing adjustments to be made at each stage based on the results observed and the needs identified.

3.5. Proposal for a training program:

The incorporation of a training program is a key element in ensuring the correct implementation and sustainability of the Document Management System [DMS] in the System Coordination. Staff training ensures that each member understands their documentary responsibilities, the proper use of formats, the traceability of information, and compliance with established guidelines.

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3.6. Proposed internal audit program:

The purpose of this audit is to verify that the elements of the system, as well as its document structure, version control, nomenclature, preservation, and access, are aligned with the criteria defined in the document management manual and with the requirements established in Article 7.5 of ISO 9001:2015.

3.7. SGD Manual:

As a result of the work carried out in the previous objectives, we present the Document Management System [DMS] Manual designed for the Coordination of the Irapuato Integrated Transport System of the General Directorate of Mobility and Transport. This document integrates in a structured manner all the theoretical elements proposed during the project: from the document structure, operating procedures, and technical guidelines to the policies for access, conservation, and control of documents.

The purpose of the manual is to serve as an institutional guide for organizing, controlling, and improving the management of documented information, ensuring its traceability, accessibility, and regulatory compliance based on Article 7.5 of ISO 9001:2015.

The contents of the Manual are shown below, see figures 13, 14, and 15:

Box 13

Figure 11
SGD Manual Cover

Box 14

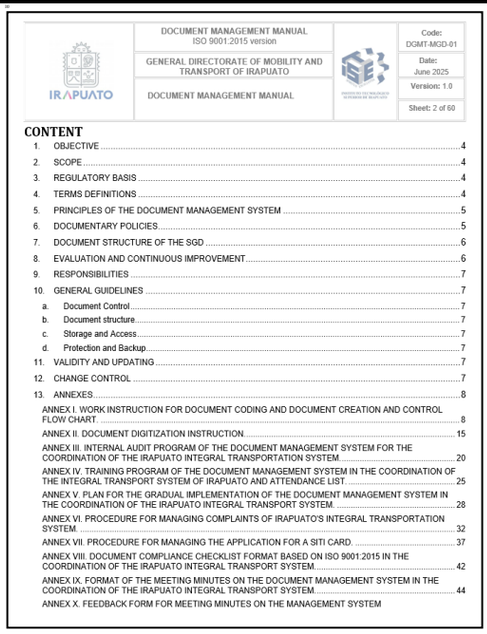

Figure 12
Contents of the SGD Manual

Box 15

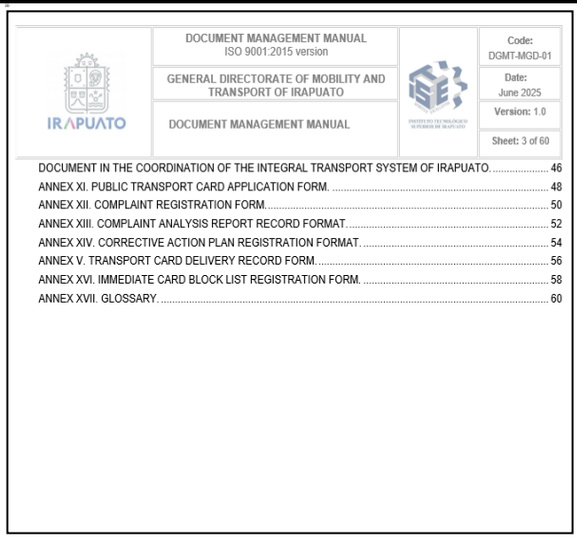

Figure 13
Contents of the SGD Manual

3.8. Proposals for digital tools for data storage:

For document collection, data storage, and collaborative access, two digital tools are proposed, which are defined above:

Figure 16 shows Microsoft SharePoint with custom permissions and document flow automation, ideal for institutions that require traceability.

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Box 16

Figure 14

Microsoft SharePoint, página para coordinación de SITI

Figure 17 shows Google Drive with cloud storage, which allowed us to securely store, organize, and share files, with agile information management.

Box 17

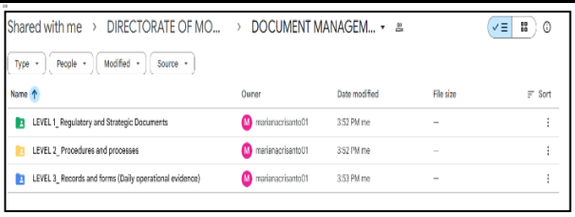

Figure 15

Google Drive, page for the Directorate of Mobility and Transportation of Irapuato

Source: own elaboration

Both tools are accessible, scalable, and secure, making them viable options for improving document efficiency and collaborative work.

Recommendations

It is recommended to start implementing the system gradually, beginning with the validation and adaptation of the document structure, giving priority to areas such as card issuance and complaint management. It is also advisable to use the manual as a basis for future actions, allowing for adaptations without losing alignment with ISO 9001:2015.

In addition, train the staff responsible for document management and the SITIPago system to improve communication with users and conduct regular internal audits to ensure compliance with the proposed system in order to identify areas for improvement and adopt digital tools that facilitate document management.

Conclusions

The project arose in response to the documentation problems faced by the public transport prepaid card system, which hinders efficient and equitable access to the service.
In light of this situation, a structured proposal for a Document Management System was designed, based on the principles of ISO 9001:2015.

This standard establishes clear guidelines to ensure that all documented information is accessible, reliable, and well organized. Through an initial diagnosis, several problems were identified, such as the lack of clear procedures, errors in record management, and the absence of a defined document structure. Based on this analysis, a technical manual was created containing the complete proposal for the document system, designed especially for the comprehensive transportation system coordination department.

This manual includes key elements such as document hierarchy, access policies, version control, and standardized procedures.

Annexes

Box 18

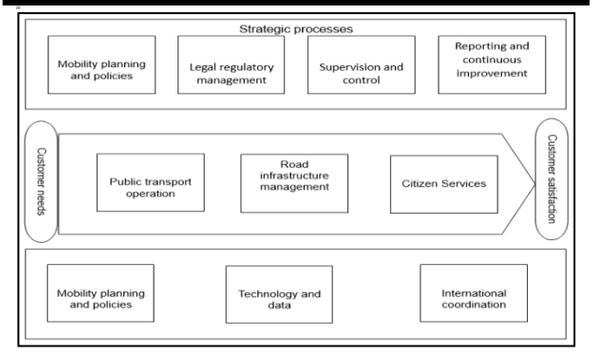

Figure 16

Process map of the General Directorate of Mobility and Transportation of Irapuato

Source: own elaboration

Box 19

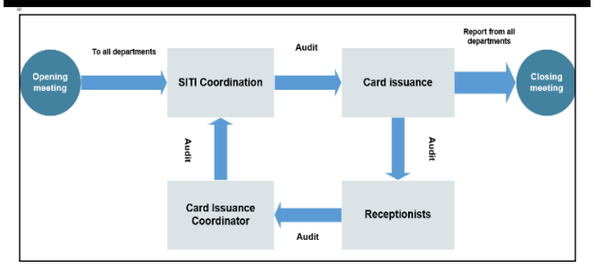

Figure 17

Block diagram, audit flow

Source: own elaboration

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Declarations

Conflict 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.

Author contribution

Espinosa-Sánchez-Adriana: Contributed to the project idea, method, and research technique.

Vargas-Rodríguez-Bertha-Laura: Contributed to reviewing the research structure and developing the methodology used.

Jaime-Cabello-Emilio: Contributed to field research, conducting surveys and interviews with transportation system personnel in Irapuato.

Availability of data and materials

The data obtained in the course of this research, related to document management in accordance with ISO 9001:2015 for the Coordination of Integrated Transport in Irapuato, is available for consultation upon request.

This information includes interviews, process analyses, internal documentation, and records generated during the diagnosis and proposal of the document management system.

Due to the institutional and confidential nature of some of the data, its availability is subject to approval by the Comprehensive Transportation Coordination and compliance with the guidelines established by that entity.

Those interested in accessing this information should contact the project manager or the institution.

Funding

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Abbreviations

NRTec	Desarrollos tecnológicos
SIPOC	Suppliers, Inputs, Process, Outputs, Customers
SITIpago	Sistema de tarjeta prepagada SGD Sistema de Gestión Documental

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Article

Technology transfer in inventory and order management in automotive parts stores

Transferencia de tecnología en la gestión de inventarios y pedidos en refaccionarias automotrices

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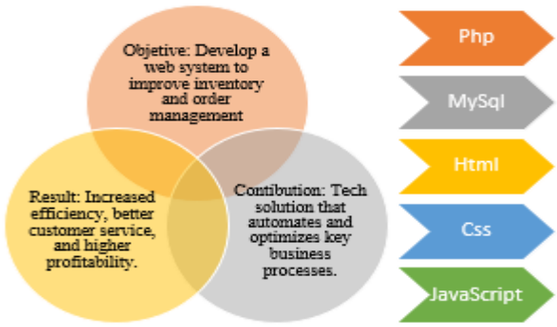
Abstract

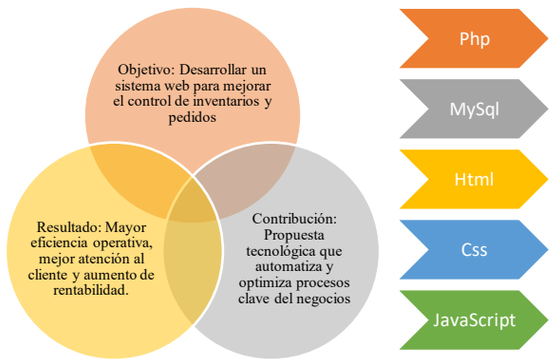
Currently, the business "MELQUIAS AUTOMOTRIZ," located in Salamanca, Gto., is facing serious operational difficulties due to poor inventory control and errors in order management, despite having a digital system in place. The lack of accurate records leads to mistakes when fulfilling orders, resulting in financial losses and customer dissatisfaction. To address this issue, the development of a web-based system for inventory control and order management is proposed. This system will allow for the registration of incoming and outgoing products, efficient order handling, and the generation of detailed reports on sales, suppliers, and customers. The proposed solution aims to improve inventory accuracy, customer service, and overall business profitability. This research seeks to demonstrate that the adoption of appropriate technologies can positively transform the operations of automotive parts businesses.



Php, MySql, Administration, Software

Resumen

Actualmente, el negocio "MELQUIAS AUTOMOTRIZ", ubicado en Salamanca, Gto., enfrenta serias dificultades operativas debido a un deficiente control de inventarios y errores en la gestión de pedidos, a pesar de contar con un sistema digital. La falta de registros precisos ocasiona errores al surtir pedidos, generando pérdidas económicas e insatisfacción en los clientes. Ante esta situación, se propone desarrollar un sistema web para el control de inventarios y administración de pedidos, que permita registrar entradas y salidas, gestionar pedidos eficientemente y generar reportes de ventas, proveedores y clientes. Esta solución mejorará la precisión del inventario, la atención al cliente y la rentabilidad del negocio. La investigación busca demostrar que la implementación de tecnologías adecuadas puede transformar de manera positiva la operación de refaccionarias automotrices.



Php, MySql, Administración, Software

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

Citation: Sánchez-Luna, Antonio, Rodríguez-Campos, Juan Carlos and Rico-Chagollán Mariana. [2025]. Technology transfer in inventory and order management in automotive parts stores. Journal Applied Computing. 9[23]1-9: e5923109.

Introduction

This project addresses the main problems faced by the spare parts store, such as uncontrolled inventory, inefficient order management, and frequent delivery errors. Through the implementation of a web-based inventory control and order management system, the aim is to improve the company's operational efficiency, optimise inventory management, and reduce delivery times. It also seeks to provide a solution that improves the customer experience, consolidates the spare parts store's competitiveness, and provides a solid foundation for its future growth.

Software

Instructions [computer programs] that, when executed, provide the desired features, function, and performance; data structures that allow programs to manipulate information appropriately; descriptive information in both paper and virtual forms that describe the operation and use of the programs.

JavaScript

JavaScript [JS] is a lightweight, interpreted, or just-in-time compiled programming language with first-class functions. Although it is best known as a scripting language for web pages, and is used in many non-browser environments, such as Node.js, Apache CouchDB, and Adobe Acrobat, JavaScript is a prototype-based, multi-paradigm, single-threaded, dynamic programming language with support for object-oriented, imperative, and declarative programming.

Programming language

A programming language is a formal language that provides a set of instructions that allow a programmer to write sequences of commands and algorithms to control the physical and logical behaviour of a computer in order to produce various types of data. This set of commands and data written in a programming language is known as a programme.

Database

A database is a set of data belonging to the same context and stored systematically for later use.

Visual Studio Code

Visual Studio Code is a distribution of the Code - OSS repository with specific Microsoft customisations released under a traditional Microsoft product licence. It combines the simplicity of a code editor with what developers need for their basic edit-compile-debug cycle. It provides comprehensive code editing, navigation and comprehension support along with lightweight debugging, a rich extensibility model and lightweight integration with existing tools. There is no cost to access its features.

HTML 5

This is the markup language we use to structure and give meaning to our web content, for example, by defining paragraphs, headings and data tables, or inserting images and videos into the page. [Mdn Web Doc, Network, 2005].

CSS

This is a style rule language that we use to apply style to our HTML content, for example, setting background colours and font types, and distributing our content across multiple columns.

Life Cycle

The software life cycle consists of the set of stages that precede and follow programming. Software engineering methods and techniques fall within the framework defined by the software life cycle and, more specifically, by the different stages that can be distinguished.

Web Browser

A computer program that allows users to access the web pages they want, provided they know the URL address where they are located [e.g. www.google.com] or click on a hyperlink that leads to that page.

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Jquery

A fast and concise JavaScript library that simplifies HTML document, event handling, animation, and AJAX interactions for web development.

Server

Definition Server [software]: A software-based server is a programme that provides a special service that other programmes called clients can use locally or over a network. The type of service depends on the type of server software. The basis of communication is the client-server model, and service-specific transmission protocols come into play when it comes to data exchange. .

MySQL

This is the name of a system that allows for the management of databases. It is the most widely used option for web-based applications. [Pérez Porto, 2019].

PhpMyAdmin

This is a tool written in PHP with the intention of managing MySQL administration through web pages, using the Internet. It is available under the GPL [General Public Licence] and in more than 50 languages. This project has been in existence since 1998.

Xampp

XAMPP is the most popular PHP development environment. XAMPP is a completely free and easy-to-install Apache distribution that contains MariaDB, PHP, and Perl. The XAMPP installation package has been designed to be incredibly easy to install and use.

Methodology

In this project, the waterfall life cycle was used because it is suitable for the development of the web platform in the degree awarding processes. It provides a clear and sequential structure that facilitates project planning and management.

Each phase, from requirements analysis, design, implementation, testing, to maintenance, is completed before moving on to the next, minimising the possibility of unforeseen changes and allowing for better risk management.

Box 1

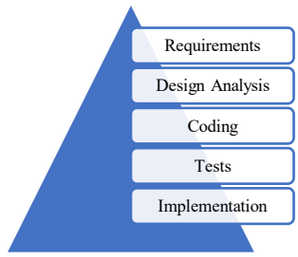

Figure 1
Cascading Life Cycle
Source: Own elaboration

Figure 1 shows the iterative cycle methodology especially useful in projects where the feedback obtained in each phase should improve the previous one.

Therefore, by choosing the iterative cycle, we proceed to show the activities in the table below for the definition of the processes and their stages. This structured methodology ensures that each phase is completed before moving on to the next, allowing for an orderly and controlled development of the project. As shown in Table 1.

Box 2

Table 1
Activity and stages of the cycle.

Stage	Objective	Procedure
Planning and Analysis	Identify needs, define objectives and scope.	Analysis of current problems. - Compilation of requirements.
Design	Establish the structure and detailed design of the system.	Interface design with HTML5, CSS3 and Template
Development	Build the system according to the requirements and design.	Programming of the graphic interface.
Testing	Validate operation and detect errors.	- Unit testing and integration.
Implementation	Deploy the system and train users.	Data migration from the previous system.
Maintenance	Ensure continuous operation and future enhancements.	Corrective maintenance.
Evaluation	Measure impact and collect feedback.	Operational efficiency analysis.

Source: Own elaboration

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Analysis

1. Planning and Analysis Phase.

Objective: Define system objectives, business requirements, and project scope.

- Problem Analysis: Evaluate the current problems of the spare parts store, such as lack of inventory control and inefficient order management.
- Definition of Requirements: Identify customer needs and the functional and non-functional requirements of the system.
- Project Scope: Establish the scope of the system based on the Frontend, Processes and Backend layers, ensuring that the system is scalable and modular.
- Project Planning: Develop timelines, necessary resources, and deliverables for each phase of the project.

2. Design Phase

Objective: Establish the system architecture and detailed design of its components.

- System Architecture: The modular structure of the system is defined, clearly separating the three layers [Frontend, Processes, and Backend], which allows the system to maintain its independence and flexibility.
- User Interface Design [Frontend]: Using HTML5, CSS3, and the Celestial Template, an attractive and functional visual interface is created.
- Database Design [Backend]: The data model is created in MySQL 10, ensuring that the database is scalable and efficient.
- Functionality Specification: The interactions between the layers, data flow and system features are specified, using PHP 8.3, JavaScript ECM6 and jQuery to process and manage the information.

3. Development Phase

Objective: To build and programme the system in accordance with the previously defined requirements and design.

- Frontend Development: The user interface is built with HTML5, CSS3 and Template Celestial, ensuring that the user experience is intuitive and efficient.
- Process Logic Development: The interaction layer between the frontend and backend is implemented, using JavaScript ECM6 and jQuery for dynamic interactions and PHP for data processing logic.
- Backend Development: The server and database are configured using PHP 8.3 and MySQL 10, establishing the functionalities to manage inventory, orders, and customers efficiently.

4. Testing Phase

Objective: To verify that the system works correctly and meets the specified requirements.

- Unit Testing: Tests are performed on individual components of the system to ensure that each part functions as expected [frontend, processes, and backend].
- Integration Testing: The interaction between the different layers of the system is verified, ensuring that data flows correctly between the frontend, backend, and database.
- User Testing: Usability and user experience tests are performed to ensure that the interface is intuitive and easy to navigate.
- Security Testing: Tests are performed to identify potential vulnerabilities in the system, with a special emphasis on protecting customer data and transactions.

5. Implementation Phase

Objective: Deploy the system in the production environment and make it available to end users.

- System Deployment: The system is installed on the production servers, configuring the databases and ensuring that all components are correctly integrated.
- User Training: Parts store staff are trained in the use of the new system, including inventory management, ordering, and reporting.
- Data Migration: If necessary, data is migrated from the old system to the new one, ensuring that no important information is lost.

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6. Maintenance Phase

Objective: To ensure the continuous operation of the system and adapt it to future needs.

Corrective Maintenance: Errors that may arise during the use of the system are managed and corrected.

Evolutionary Maintenance: New functionalities and improvements are implemented in the system according to business needs and user suggestions.

- Technology Updates: Underlying technologies [PHP, MySQL, etc.] are updated to keep the system secure, efficient, and compatible with new versions.

7. Evaluation Phase

Objective: To evaluate the system's performance and its impact on the auto parts store.

- Performance Evaluation: The impact of the system on the spare parts shop's operational efficiency is measured, including accuracy in inventory control, reduction of ordering errors, and increased customer satisfaction.
- User Feedback: Feedback is collected from employees and customers to identify potential areas for improvement and optimisation.

Conclusion

The project life cycle follows a structured and modular approach that allows for efficient and scalable development of the inventory control and order management system. Each phase is geared towards ensuring the quality of the system and its suitability for the business needs, allowing the spare parts store to improve its operations, increase customer satisfaction, and optimise its sales and inventory management processes.

The life cycle that best suits the development of a web-based inventory control and order management system is the Waterfall Life Cycle or the Iterative and Incremental Life Cycle. Both approaches are commonly used for software projects and have features that can be tailored to the needs of this type of system.

Box 3

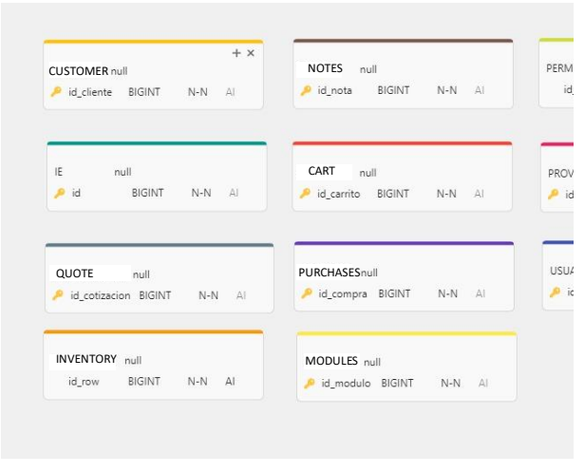

Figure 2

Database design

Source: Own elaboration

Figure 2 shows the final structure of the database, which was designed to ensure efficient data management, facilitate future extensions and improve the overall performance of the system.

Box 4

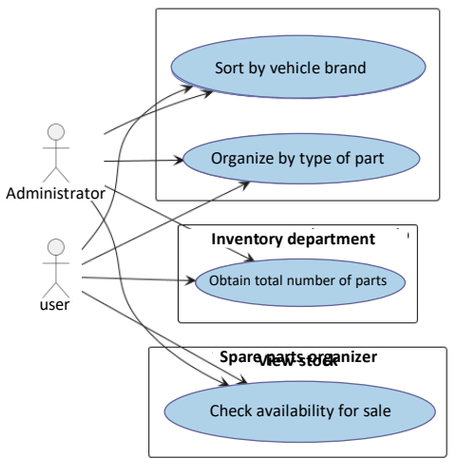

Figure 3

General system use case diagram

Source: Own elaboration

The use case diagram in figure 3 describes the functionalities for organising and sorting spare parts in the system. Both the administrator and the user can perform four main actions: organise parts by part type, sort parts by vehicle make, obtain the total parts in inventory, and check parts availability for sale. This allows for efficient inventory management and facilitates decision making on parts available for sale.

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This system is designed to manage different processes related to the administration of sales, vehicles, inventory, parts, customers and suppliers. It has two types of users: the common user and the administrator. The common user can generate invoices, register sales, check stock, update inventory, consult vehicle data and generate reports.

The administrator has full access to the system, including the ability to register and query vehicles, parts and customers, as well as manage suppliers, register purchases and also generate reports. Thanks to this structure, the system allows the centralisation and efficient organisation of the organisation's key operations, providing comprehensive control and facilitating decision making.

Box 5

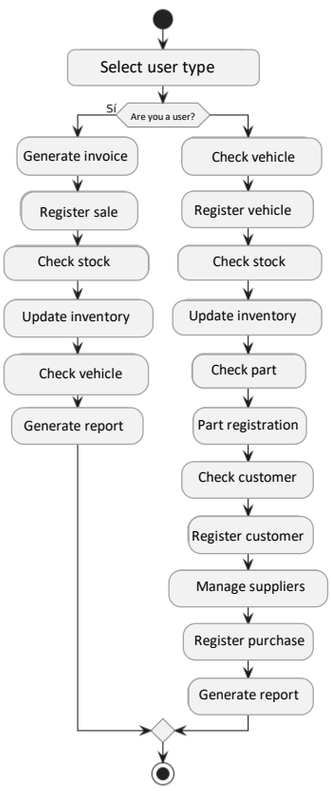

Figure 4
Coding [Backend]

Source: Own elaboration

Figure 4 describes the business process of the system that manages sales, inventory, and purchases, differentiating the workflow according to user type.

It begins with the selection of the user type, which branches the process into two main paths:

1. A flow for sales/billing users [Generate Invoice, Record Sale, Update Inventory, Generate Report].
2. A more comprehensive flow for inventory/purchasing management users [Consult/Register Vehicles and Parts, Manage Suppliers, Register Purchase, Update Inventory, Generate Report].

Results

Design User control

The user section, shown in Figure 5, is essential for system administration. In this section, you can manage user changes to access the system, as well as grant the necessary permissions to interact with and manipulate it as required. To perform these actions, the system only requests three pieces of information: name, user, and profile.

Box 6

Figure 5
User Administrator

Input control and output control

This section of the system allows for the efficient management of related operations, providing an intuitive interface for monitoring, recording and updating related information. From here, users can make necessary adjustments, verify details of specific purchases and ensure that data is correctly synchronised with the rest of the system, thus facilitating a comprehensive and accurate control of receipts.

Box 7

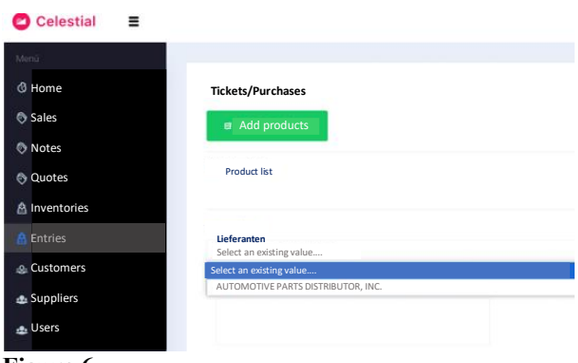

Figure 6
Inputs and Outputs [Administrator role]

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Box 8

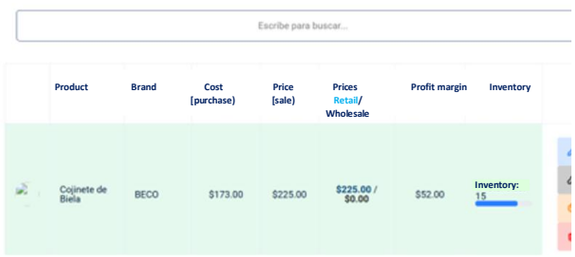

Figure 7
Inventory Control
Source: Own elaboration

In figure 7, inventory control allows to manage and update the inventory in an efficient way by feeding the product catalogue. To add new products, simply click on the "Add new" option. In this section, it is required to enter relevant product information, such as name, brand, product type, cost price and selling price, this process in a visual way, making it easy to understand.

Sales control

The "Sales" section, shown in figure 8, facilitates the direct generation of a new sale. When interacting with this section and using the corresponding button, the inventory is displayed along with visual controls in colours that highlight relevant information. These indicators provide key data that help to make quick and accurate decisions, optimising the sales process and improving the user experience.

Box 9

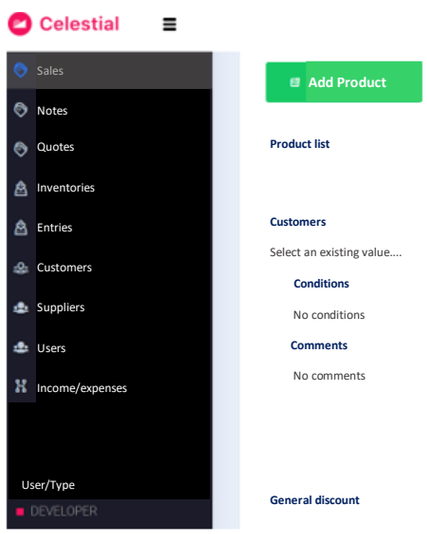

Figure 8
Sales control
Source: Own elaboration

Figure 9 shows how the customer data, the type and conditions of payment, as well as the discount rates and the date on which the transaction took place are displayed.

Box 10

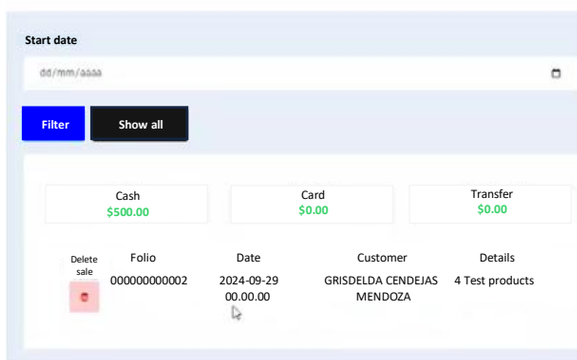

Figure 9
Note management
Source: Own elaboration

Finally, in figure 10 we can see how the sales note has been generated, where several sections and sections that were previously fed at the time of being with the customer during the sales process appear. And this generates at the end, the note that will be delivered to the client.

Box 11

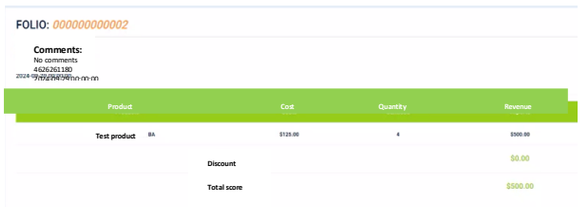

Figure 10
Note Generation
Source: Own elaboration

Data Analysis

Social Impact

The implementation of the inventory control and order management system will have a positive impact on the customer experience, as it will ensure the availability of spare parts when needed, reducing dissatisfaction and strengthening confidence in the company. In addition, the staff at 'MELQUIAS AUTOMOTRIZ' will benefit from a reduction in workload by minimising errors in inventory control and orders.

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The digitisation of the process will also encourage the development of new technological skills among employees, which will increase their efficiency within the company and provide them with tools that can improve their performance and employability in the future.

Economic Impact

The project will improve the profitability of the business by reducing economic losses resulting from errors in inventory management. More efficient administration will prevent unnecessary purchases or shortages of key products, optimising operating costs. In addition, better order management will increase customer satisfaction, which can translate into greater loyalty and sales growth. The ability to generate detailed reports on suppliers and customers will identify opportunities for improvement in business relationships, optimising supply and reducing additional costs.

Scientific Impact

From a scientific perspective, this project will contribute to the study and development of best practices in inventory management within small and medium-sized enterprises in the automotive sector. The collection and analysis of data on sales, orders, and customer management will generate valuable information for future research on business digitisation. In addition, the experience gained in implementing the system can serve as a reference for studies focused on process optimisation and the application of new technologies to improve operational efficiency in similar businesses.

Technological Impact

The proposed system will drive digital transformation in the company by integrating advanced tools for inventory and order management. The use of a web platform will allow real-time access to information, improving decision-making and streamlining administrative processes. In the long term, this system will be able to evolve with the incorporation of emerging technologies such as artificial intelligence or the Internet of Things [IoT], which will facilitate even more efficient and automated business management.

Conclusions

In conclusion, the problems identified in this study show that the 'MELQUIAS AUTOMOTRIZ' auto parts store faces serious operational challenges due to a lack of efficient inventory control and inadequate order management. These deficiencies have a negative impact on both customer satisfaction and the profitability and competitiveness of the business.

The research focused on developing a proposal based on a web-based system for inventory and order management, with the aim of optimising operations and solving the problems detected. Critical issues such as inaccurate stock records, errors in order fulfilment and the lack of tools to efficiently manage sales were addressed. In addition, specific solutions were proposed, such as automated merchandise control, the generation of detailed reports, and the agile issuance of quotes and payment notes, successfully addressing key areas of opportunity.

In summary, this study demonstrates that the implementation of appropriate technologies, such as a web-based inventory and order control system, can significantly transform the operations of an automotive parts store. This not only increases operational efficiency and facilitates decision-making, but also improves the customer experience and strengthens the company's competitive position. With this solution, 'MELQUIAS AUTOMOTRIZ' has the capacity to grow sustainably, face the challenges of today's market, and ensure high-quality service for its customers.

Declarations

Conflict of interest

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

Contribution of the authors

Sánchez-Luna, Antonio, I contributed to the collection of system analyses, project ideas, and communication between the client and the developer.

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Rodríguez-Campos, Juan Carlos: I contributed to the development of the project, data analysis, and interface relationship.

Rico-Chagollán, Mariana: I contributed to the review of the project in the final tests.

Availability of data and materials

Further information on the availability of data or programming methodology during this study is available from the author.

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Abbreviations

CouchDB	Cluster Of Unreliable Commodity Hardware
AJAX	Asynchronous JavaScript and XML
CSS	Cascading Style Sheets
HTML	HyperText Markup Language
ITESI	Tecnológico Superior de Irapuato
JSON	JavaScript Object Notation
MySQL	My Structured Query Language
PHP	Hypertext Preprocessor
SQL	Structured Query Language
TecNM	Tecnológico Nacional de México
X [de XAMPP]	Cross-platform [Multiplataforma: Windows, Linux, macOS]
A [de XAMPP]	Apache [Servidor web]
M [de XAMPP]	MySQL o MariaDB [Base de datos]
P [1° P de XAMPP]	PHP [Lenguaje de programación del lado del servidor]
P [2° P de XAMPP]	Perl [Otro lenguaje de programación]

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Article

Educational IoT platform under DevOps methodology

Plataforma Educativa IoT bajo la metodología DevOps

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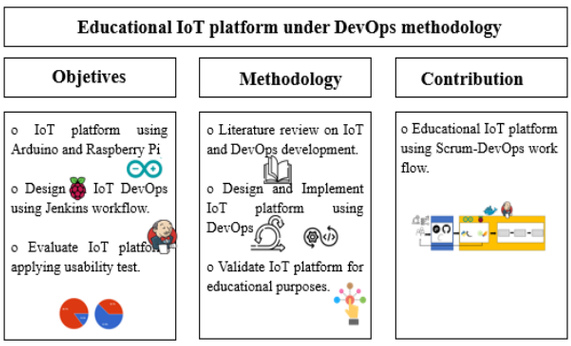
Abstract

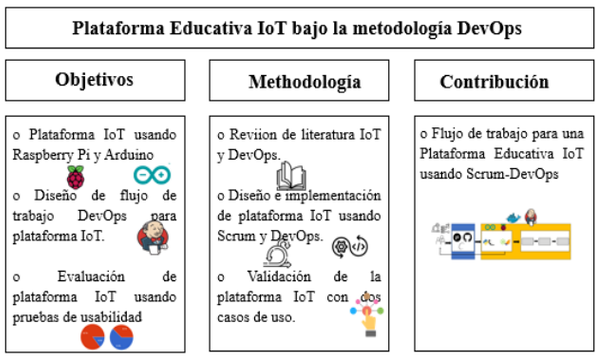
Electronics has evolved significantly through connectivity. Various devices with these capabilities exist, such as Raspberry Pi, Arduino, ESPs, and minicomputers. The Internet of Things [IoT] is the term used to encompass such devices. This technology includes sensors, actuators, communication protocols, user interfaces, data processing, security, administration and management. The industry has developed IoT cl platforms such as Arduino Cloud, AWS IoT, and Azure IoT. Implementing such platforms requires expertise in software development, communications, and electronics. This paper proposes the design and implementation general-purpose IoT platform under DevOps methodology.



Internet of things, Educational Platform, DevOps.

Resumen

Actualmente la electrónica ha evolucionado a través de la conectividad y se encuentra por todos lados [industria, vida diaria]. Existen distintos dispositivos en el mercado con estas capacidades como Raspberry Pi, Arduino, ESP o minicomputadoras. Internet de las cosas [IoT] es el término acuñado para englobar estos dispositivos. Esta tecnología incluye sensores, actuadores, protocolos de comunicación, interfaces de usuario, procesamiento de datos, seguridad, administración y gestión. La industria ha desarrollado plataformas como Arduino cloud, AWS IoT o Azure IoT. En este trabajo se propone el diseño e implementación de una plataforma IoT de propósito general bajo la metodología DevOps.



Internet de las cosas, Plataforma educativa, DevOps

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

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Introduction

The Internet of Things is a technology that enables devices to connect to each other and has found applications in manufacturing, healthcare, retail, transport, logistics, energy and agriculture [Wei, 2024]. This technology has seen a huge increase in connected devices, from 10.3 billion in 2018 to 25 billion in 2025. In terms of data volume, 86 petabytes [PB] of information were generated in 2022, and it is estimated that more than 1,100 PB will be generated in 2027. This technology is one of the main resources that feed artificial intelligence [AI] models and cloud computing [Flinders & Smalley, 2025].

From a socio-technological point of view, it encompasses different business opportunities based on this technology, including: hardware, software, networks, integrated platforms, standards and data analysis [Krotov, 2017].

The area of opportunity for IoT is so vast that platforms such as AWS IoT, Microsoft Azure IoT Hub, Google Cloud IoT, ThingWorx [PTC] IIoT, IBM Watson IoT, and Oracle IoT have been developed, to name a few. The work carried out by [Panagou et al., 2025] presents a comparative study of the most important characteristics of an IoT platform. The factors considered in their study are: 1] security, 2] scalability and performance, 3] interoperability, 4] data analysis and AI/ML integration, 5] edge computing support, 6] cost model and price-benefit ratio, 7] development tools and SDK support, 8] norms and standards, 9] OTA update capability.

With regard to IoT platform development methodologies, an analysis of platform design for the agro-industrial sector with interoperability as the main feature is described in [Muños et al., 2025]. In the same vein, a layer-based taxonomy is presented in [Arnold et al., 2022]. The taxonomy consists of:

- Infrastructure layer, which includes hardware, host, and data processing;
- Network layer, which includes physical data transfer and logical data transfer;
- Mediation layer, which incorporates data structure, data analysis type, analysis technology, external integration, and platform source code;
- Application layer, which includes APIs, implementation, and business.

Two of the most widely used platforms in academia due to their accessibility and cost are Arduino and Raspberry, [Arduino - Home, n.d., Raspberry – Home, n.d.]. These offer hardware, software, and a cloud platform and have a large academic community. The Arduino platform has strategic partners ranging from components to distribution: Adafruit Industries, SparkFun Electronics, Seeed Studio, DFRobot, Mouser Electronics, Element14, Tindie, and RobotShop. Currently, Qualcomm is one of the world's leading semiconductor and wireless technology companies. It has acquired Arduino, announcing the addition of AI, graphics and processing capabilities [Arduino – Qualcomm, n.d.].

Raspberry Pi already has networking, processing, AI, and graphics capabilities. It also has a wide range of components, from video cameras to screens. Another component that is also used in academia is the ESP32, which offers connectivity, software, hardware, and a cloud platform [Espressif Systems, n.d.].

The data ports offered by these components are:

- digital input-output,
- analogue input-output,
- I2C communication,
- serial communication,
- SPI communication,
- among others such as GPIO in the case of Raspberry Pi.

Therefore, any sensor or component with these characteristics can be connected to these devices. Having access to networks, whether via Ethernet or Wi-Fi, allows connection to the internet, which facilitates web development, REST services, or cloud services.

This work is divided into the following sections: problem statement, DevOps review [Singh, 2023], physical architecture design, logical architecture design, DevOps development and product list, DevOps sprint, case studies of platform use, and finally results and conclusions.

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Problem statement

The Internet of Things is a reality both at home and in industry, although there are commercial platforms that offer IoT services. In the particular case of education, it is important to know this technology as part of job skills, but something more interesting is to study its development.

To implement an IoT platform, it is necessary to have expertise in different areas of knowledge such as software development, electronics, communications, automation, data analysis, project management and administration, to name a few. This article proposes the design and development of a general-purpose IoT platform based on Raspberry Pi and Arduino using the DevOps methodology.

The main interest of this project is to have a platform for the development of academic projects and to promote participation in student project calls. In addition, from an academic point of view, it incorporates the use of development technologies used in the workplace, such as: Scrum, DevOps, version control system [Git], networks, web services, front-end development, embedded devices, Python, HTML, CSS, and JavaScript.

DevOps Review

DevOps is a set of practices that promotes collaboration between development and operations teams in the life cycle of a software project [Singh, 2023; Lindemulder, G., & Kosinsk, 2025; Leszko, 2022; Erich et al., 2017]. DevOps adds new processes to agile methodologies, particularly CI/CD [continuous integration/continuous delivery] automation. The steps in the DevOps development lifecycle are as follows:

1. Planning: new features and functions.
2. Scheduling: the DevOps team develops the sprint according to the stories on the product list.
3. Building: new functionalities are integrated into the existing code, tests are performed, the new system is packaged and deployed.
4. Testing: tests are performed, usually automated, to verify that the appropriate standards and requirements are met.
5. Deployment: final tests are applied so that users can access the new software.
6. Implementation: the project moves into production.
7. Operation: the new project features are verified to ensure they work correctly and are available to users.
8. Monitoring: user feedback is collected and analysed, as well as lessons learned from the sprint, to improve future processes and products.

In particular, CI requires frequent code integration into a central repository and automated building and testing. This allows for rapid problem detection and feedback. CD provides functional software and enables proper management between speed of delivery and change control. CD can have two meanings: continuous delivery or continuous deployment. In this work, we will use continuous delivery.

There are many options on the market for implementing DevOps, particularly for implementing CI/CD. However, due to the academic nature of this work, it is necessary to design and implement a local infrastructure and use free tools. The tools we will use in this project are: Docker, Jenkins, GitHub, Openssl, Python, Flask, Jakarta, NodeJS, Glassfish, and Postgresql. In terms of hardware: computer, access point, Raspberry Pi, Arduino, compatible sensors and actuators.

Design of the physical architecture of IoT: Hardware

The physical components that make up the platform are: a] a computer that has the function of maintaining the system versions, configured with Docker, Jenkins, GitHub, and ssh keys; b] Raspberry Pi [there may be several], which has the function of reading sensors, controlling actuators, and communicating with the Arduino; and c] a client computer, where users use the platform to create their own projects. It uses the available software-hardware components, creates a web application to control its sensors or actuators, and creates and publishes new UI components and their physical configurations. It has a local repository for the development of its applications. The physical architecture is shown in Figure 1.

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Box 1

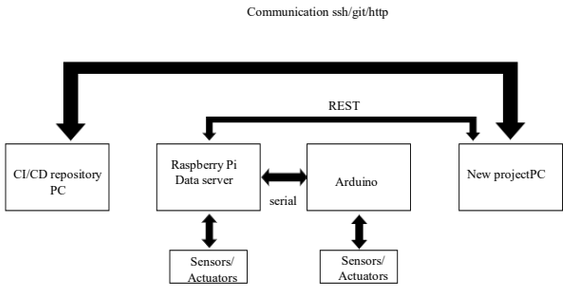

Figure 1

IoT diagram of physical components and their communication scheme: CI/CD repository, Raspberry Pi, Arduino, sensors-actuators, client.

Designing the logical architecture of IoT: Software

Code developers and testers are responsible for developing the system. Developers are generally responsible for writing and integrating code. The role of code tester has a major influence on the efficiency and quality of the CI/CD flow. This is because they have a perspective that helps the entire team avoid delays, reduce errors, and are responsible for the user experience. In addition, they define the acceptance/failure criteria. Therefore, they are responsible for promoting continuous improvement.

Within DevOps development, the CI/CD flow is important as it involves steps 2] programming, 3] building, 4] testing, and 5] deployment. Figure 2 shows how the development team programs code and submits it to the version management system, after which the server builds and performs tests. If there are errors, feedback is sent to the development team.

If there are no errors, it moves on to the CD block, where the code is put on hold to be tested against the acceptance criteria. Finally, it is published or goes into production. In our case, it is only published, as the users are the ones who will use these versions for their projects.

Box 2

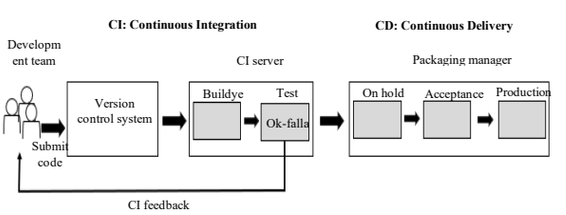

Figure 2

CI/CD DevOps flow diagram.

DevOps development team and initial product list

Specifically, the development team programmes new features based on the updated product list and then defines Sprints. The aim of this work is to develop an IoT platform using Raspberry Pi and Arduino for academic projects, incorporating sensors, actuators and a web-based UI component system. From the above, the initial product list consists of the following epics:

E0. Configuration of the working environment.

E1. Read data from temperature-humidity sensors, gyroscope, speed, GPS, fingerprint, buttons and distance using Arduino. Document connection diagrams and code.

E2. Control actuators such as motors and LEDs using Arduino. Document connection diagrams and code.

E3. Implement a serial communication model between Arduino and Raspberry Pi via messages.

E4. Read sensor data using Raspberry Pi. Document connection diagrams and code.

E5. Control actuators using Raspberry Pi. Document connection diagrams and code.

E6. Implement REST services to read sensor data or control actuators, Arduino or Raspberry Pi.

E7. Implement UI components to access REST servers for sensors and actuators.

The following tools are used for programming, construction and testing:

- Arduino Studio is used for Arduino,
- Python is used for Raspberry coding,
- Flask is used for REST services,
- Jakarta-PrimeFaces and NodeJS are used for UI components,
- GitHub-Git is used as a code management tool,
- Jenkins is used as a tool for building, testing and packaging code.

Figure 3 shows the workflow with the specific tools.

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Box 3

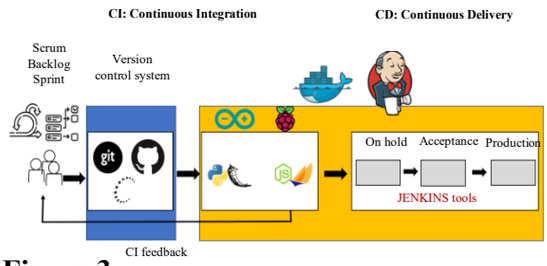

Figure 3

DevOps CI/CD flow diagram: the team performs Sprints, submits code to GitHub using a secure ssh connection. A Docker-Jenkins container configured for CI/CD. For testing, there is an Arduino-Raspberry system configured with Python, Flask, NodeJS, and Jakarta. Tools provided by Jenkins are used for the CD stage.

Own creation

For step 8] monitoring and CI feedback, Jenkins notification tools are used. Specifically in Jenkins, the CI workflow consists of [Leszko, 2022]:

- Triggers: the way in which the flow is executed. It can be caused by an external event, in our case a commit to GitHub.
- Stages: each stage is composed of steps that perform a simple operation. A stage can be, for example, building, testing, or releasing.
- Notifications: this is how Jenkins announces the status of the stages. This can be by email, chat, or in workspaces. The workspace creates boards that are visible to all team members, or it can also be a virtual board.
- In our case, we implemented the most fundamental workflow structure called 'commit,' which consists of:
- Verification: in this stage, the source code is downloaded from the repository.
- Compile-interpret: this stage compiles the code, if applicable. Arduino code is compiled, Python code is interpreted, NodeJS code is interpreted, and Java-Jakarta code is compiled.
- Unit testing: this stage consists of running a set of tests on the source code for validation.

DevOps for IoT platform: sprint

To keep things simple, we present the button-led development sprint. It consists of creating a circuit where a button is pressed and an LED is turned on through an Arduino circuit.

Each project carried out is accompanied by an Excel sheet containing the product list and Sprints. This can be transferred to the use of Scrum boards in tools such as Trello, Jira, Notion, Monday or any other. [Wynnedeta et al. 2024] present the development of an IoT application for sustainable environmental management based on Scrum with Raspberry Pi. In [Guerrero Ulloa et al., 2023], a review of agile tools for IoT development is conducted. Agile practices for IoT project development are presented in [Moedt van Bolhuis et. al, 2023]. These works use Scrum, and in our case, we implement DevOps.

The product list for this initial Sprint is shown in Table 1, following the aforementioned epics. For serial communication, a simple communication system was established where 'code' messages are sent, where the code refers to a sensor/actuator and a specific action.

Box 4

Table 1

Product list for the first sprint

History code	Description
E0-X-R	Configure the Raspberry Pi and connect to Arduino.
Configure	Connection diagram for the button on Arduino.
E1-S1-A Diagram	Program to read the button status.
E3-S1-A serial	Program the Arduino-Raspberry Pi communication to read the button status.
E6-S1-R rest	Program the REST service on the Raspberry Pi to read the button status.
E7-S1-C ui	Programming the UI component for the button.
E2-A1-A diagram	Diagram showing the LED connection on Arduino.
E2-A1-A program	Program to turn an LED on or off.
E3-A1-A serial	Program Arduino communication Raspberry Pi to turn the LED on or off.
E6-A1-R rest	Programming the REST service on Raspberry Pi to turn the button on and off
E7-A1-C ui	Programming the UI component for the LED.

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The stories are written briefly and assigned a code E{N}-{S/A}{M}-{D} {task}, where E refers to Epic number N, sensor S or actuator A number M [X for another case], D refers to the device [A for Arduino, R for Raspberry Pi, C for the client], and finally the task [configure: configure the working environment, diagram: electrical diagram, programme: programming the device to read/write data, serial: serial communication, rest: REST programming on Raspberry Pi, and ui: UI programming of the component].

According to the diagram in Figure 2, the code and assets generated by the sprint are submitted to the CI/CD blocks through the version control system. That system generates an event and launches the start of the CI/CD process described in the next section.

To document the functionality of each sensor/actuator, a folder is created with the following structure:

· sensor/actuator-id,
o diagram: connection diagram figure
o codeArduino: Arduino test code
o codePython: Python code
o codeREST: REST test code, also Python
o codeUI: UI component test code

DevOps for IoT platform: CD/CI

The DevOps infrastructure for our platform has a very important feature, which is hardware integration, and as such cannot be directly added to a workflow. Since hardware integration generally requires interaction with the physical environment or human intervention, automation is not very obvious. When a new feature is added to our workflow, the following steps are followed:

1] Physical connection of components to Raspberry Pi/Arduino. A connection diagram must be available.

2] Programming in Raspberry Pi/Arduino for the component to function. There are two ways to test this: a] test the availability of the resource and its functionality in its default state; b] create multiple instances of the component in different states [available, unavailable, on, off, reading, writing, etc.]. In our case, we opt for the first approach. We also design the tests, which consist of checking the availability of the component and its default state.

3] Programming the REST service for the component using Flask. We also design the tests, which in this case consist of performing REST API queries, checking availability and default state.

4] Programming the UI component, which basically involves consuming the REST data API, checking availability and its default status.
5] Committing to the repository to trigger the CI/CD process.

The default status of the components, from point 2], refers to the component being available and configured in the Arduino or Raspberry. For example, in the case of the button, its default status is ‘not pressed’.

In this work, Jenkins is used as a tool for the CI/CD flow. It consists of the following agents: agent for Arduino components, agent for Raspberry components, agent for data server, agent for UI components. Although the UI agent contains the entire workflow, it is important to have granularity in each of the steps of the proposed development cycle.

The Arduino agent is used for compilation. The Raspberry agent uses the Python agent for the data server. Finally, for the UI agent, a Java or NodeJS agent is more than sufficient. See Figure 3.

Box 5

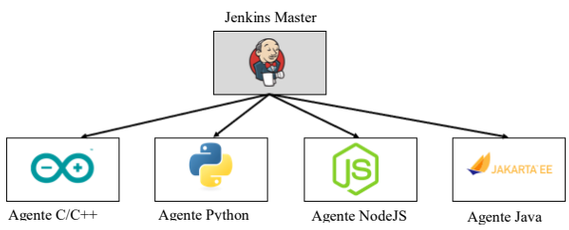

Figure 4

CI/CD agents: C/C++ for Arduino, Python for Raspberry, Java or NodeJS for UI components

Case study 1: mini weather station

In this first case study, a test group of 21 IT students was trained to use the platform. As an activity, they were asked to use the platform to create a mini weather station to measure temperature and humidity. Afterwards, the students were given a usability test for the platform. The results after the test are summarised in Table 2.

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Box 6

Table 2.

Summary of usability test results. The Likert scale used in some questions:
1- Very difficult/Confusing, 2- Difficult/Confusing, 3- Neutral/Moderate, 4- Easy, 5- Very Easy/Understandable

Phase/Question	Description
Phase 1. Experience	
Academic projects completed	Average of 1.6 projects per student
Participation in academic calls for proposals	14.3% have participated, 85.7% have not participated
Phase 2. Pre-testing	
Electrical circuits-electronics	27% have done so, 73% have not done so
Use of Raspberry Pi	36.8% have used it, 63.2% have not used it
WEB programming	89.5% have programmed it, 10.5% have not programmed it
Version control	84.2% have used it, 15.8% have not used it
Command line	89.5% have used it, 10.5% have not used it
Phase 3. Testing	
Initial configuration	1:10%, 2:30%, 3:50%, 4:5%, 5: 5%
Electrical/electronic circuitry	60% Easy/Understandable, 40% Difficult/Confusing
REST communication programming	1:5%, 2:30%, 3:60%, 4:5%, 5: 0%
WEB programming, UI components	65% Easy/Understandable, 35% Difficult/Confusing
Scrum/DevOps management	1:20%, 2:20%, 3:55%, 4:5%, 5: 0%
Phase 4. Post-test	
Overall impression of the IoT platform	1:25%, 2:30%, 3:45%, 4:0%, 5:0%
Workflow	45% Easy/Understandable, 45% Difficult/Confusing
Use of the platform in future academic projects	1:15%, 2:35%, 3:50%, 4:0%, 5:0%
Participation in academic calls for proposals	50% Easy/Understandable, 50% Difficult/Confusing

The relevant results are participation and promotion of participation in events, as shown in Figure 4. It can be seen that the use of the IoT platform is relevant to students, as they show current participation in calls for proposals of 14.3% and their intention to participate of 61.9%. Furthermore, Table 4 shows that 81% of students would incorporate the platform into future academic projects [subjects].

Box 7

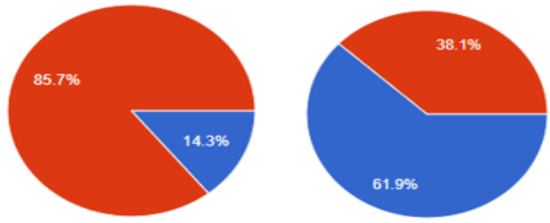

Figure 4

Left: previous participation in project calls vs Right: intention to participate after the trial

Case study 2: peregrine falcon trolley

As a case study of the platform's use, a team from the institution participated in the TecNM final in the InnoBotica category with an electric car. The participants requested support to integrate IoT tools to improve their prototype. They requested the integration of a fingerprint sensor to start the car, temperature indicators, a speed indicator, and the development of a graphical interface.

The proposal was to develop a responsive web application as a dashboard for the peregrine falcon car. A music player, voice synthesiser, and touch screen were also incorporated. In summary, the development of this project required 2HSM per member for only one month, 20 working days, 40 hours, and a team of six students. Figure 5 shows the prototype implemented in TonyKarts.

Box 8

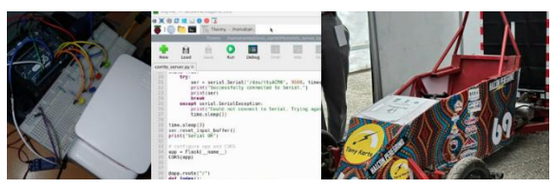

Figure 5

TonyKarts prototype participating in InnoBotica TecNM 2025

Results

This paper presented an IoT platform based on Raspberry Pi and Arduino under the DevOps methodology. To validate its functionality, two case studies were created. In the first, a test group was trained and asked to create a mini weather station. During the development of this activity, a usability test was adapted for use with the platform. The results obtained indicate that, in general, students can improve their academic projects by 81% and showed an interest in participating in calls for proposals by 61.9%.

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From an academic perspective, there is no indication of creating teaching and learning strategies through the development of educational tools. In addition to using tools that job profiles demand, the global OCC in November shows 1,040 job offers using Python, 596 using REST, 150 using NodeJS, 353 for Frontend and 546 in DevOps. Git, on the other hand, is an almost mandatory tool in software development.

There is also a microSD memory image with Raspberry configuration scripts, NodeJS environment configuration scripts, a base project for Jakarta, a Docker image configured with Jenkins for DevOps, and an Excel spreadsheet for tracking your product list using Scrum.

Conclusions

Having platforms that use current tools serves three purposes: to comply with the academic content of the subjects, to promote participation in academic events, and to strengthen the graduate profile by using tools required in current job offers. Efforts should be made to cover as many subjects as possible that integrate knowledge. This platform covers subjects such as electronics, programming, web programming, computer networks, software engineering, and project management. In addition, it promotes soft skills such as teamwork, assertive communication, independent work, document writing, responsibility, and honesty.

Although these skills were not evaluated in this project, they should be considered at the end of the project in the lessons learned section. Future work includes creating academic practices that use this type of platform in the first semesters, for example, integrating object-oriented programming, data structures, databases, and electronics projects, which are subjects taught in the first three semesters.

Declarations

Conflict of interest

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

Author contribution

Montecillo-Puente, Francisco-Javier: Contributed to the general idea of the project, development of the hardware-software platform, writing and analysis of results.

Tapia-Muñoz Alejandro contributed to hardware testing, Arduino-Raspberry programming, and document writing.

Availability of data and materials

The source code and materials can be provided upon request and agreement for academic use.

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Abbreviations

IoT	Internet of Things
PB	Peta Byte
AI	Artificial Intelligence
ML	Machine Learning
SDK	Software Development Kit
OTA	Over-The-Air
API	Application Programming Interface
I2C	Inter-Integrated Circuit
SPI	Serial Peripheral Interface
GPIO	General-Purpose Input / Output
REST	Representational State Transfer
CI	Continuous Integration
CD	Continuous Delivery
UI	User Interface

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Article

Website of medical specialties of the region Huasteca Hidalguense

Sitio web de especialidades médicas de la región Huasteca Hidalguense.

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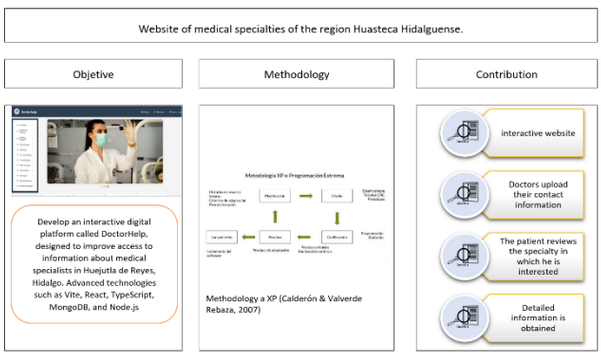
Abstract

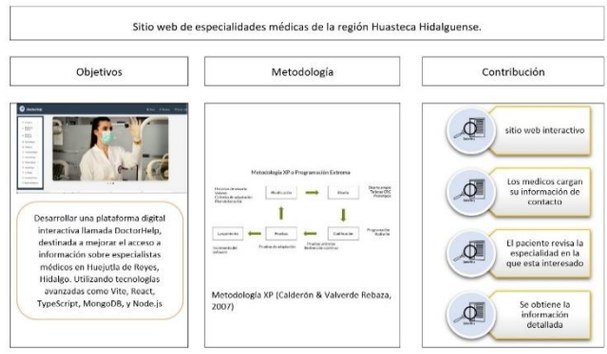
This project aimed to develop an interactive digital platform called DoctorHelp, designed to improve access to information about medical specialists in Huejutla de Reyes, Hidalgo. Advanced technologies such as Vite, React, TypeScript, MongoDB, and Node.js were implemented, along with the Extreme Programming [XP] methodology due to its focus on simplicity, effective communication, and adaptability to change, which enabled optimal project monitoring and development. As a result, an initial version of the platform was produced, intended to significantly impact access to medical information by ensuring that residents of Huejutla de Reyes can obtain fast, functional, and efficient information, adapting to user requirements.



Website, user interface, backend, Extreme Programming [XP].

Resumen

El objetivo de este proyecto fue desarrollar una plataforma digital interactiva llamada DoctorHelp, destinada a mejorar el acceso a información sobre especialistas médicos en Huejutla de Reyes, Hidalgo. Utilizando tecnologías avanzadas como Vite, React, TypeScript, MongoDB, y Node.js, Se usó la metodología Programación Extrema [XP]. por su enfoque en la simplicidad, la comunicación efectiva y la capacidad de adaptación a los cambios, lo que permitieron darle un seguimiento optimo al proyecto. Como resultado se obtuvo una primera versión del proyecto que pretende impactar notablemente en el acceso a la información médica, asegurando que los habitantes de Huejutla de Reyes puedan obtener la información rápida, funcional y eficiente, adaptándose a las demandas y necesidades de los usuarios.



Página, web, Interfaz de usuario, Backend, Extreme Programming [XP]

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

Citation: Del Carmen-Morales, Heidi, Del Carmen-Morales, Yucels Anaí, Felipe-Redondo, Ana María and Hernández-Rodríguez, Yvan de Jesús. [2025]. Website of medical specialties of the region Huasteca Hidalguense. Journal Applied Computing. 9[23]1-11: e7923111.

1. Introduction

In Mexico, the National Health System [SNS] is divided into two main sectors: public and private. The public sector is subdivided into two: systems for people with formal employment and their immediate family members [social security scheme] and systems for people without formal employment or insurance. On the other hand, the private sector is made up of various service units for people with the ability to pay. The Department of Health acts as the governing body of the system. [Díaz de León, 2020] Modernisation and conventional medical care threaten to displace ancestral practices and knowledge; however, in some regions of the country, caring for life from gestation, birth and upbringing is the work of the profound knowledge of midwives and indigenous women. [PEREZ, 2025]

The health system in Mexico plays a crucial role in the general well-being of the population, making it a highly topical and relevant issue. In a diverse and dynamic country such as Mexico, the importance of a robust and accessible health system lies not only in medical care itself, but also in its ability to address diverse challenges that affect the quality of life of millions of people. From disease prevention to efficient resource management and equitable access to medical services, Mexico's healthcare system plays an integral role in building a healthy and resilient society. [UNIR Universidad en Internet, 2023]

Knowledge about the medical specialists and healthcare services available in a region is crucial because it facilitates access to timely and effective medical care, enables disease prevention, and assists in the proper management of health problems. In the city of Huejutla de Reyes, Hidalgo, with a population of 126,781 inhabitants, 48.4% of whom are men and 51.6% women, the rate of disease in the state of Hidalgo is high and medical service coverage is scarce. In Hidalgo, the leading causes of death, reflecting the most prevalent diseases, are heart disease, diabetes mellitus, malignant tumours, influenza and pneumonia, and liver disease, according to recent data from the National Institute of Statistics and Geography [INEGI] on deaths, although there are also vector-borne diseases such as dengue fever. The rates are calculated per 100,000 inhabitants, and the specific data vary annually, but these are the chronic and acute pathologies with the greatest impact on state mortality. [INEGI, 2024]

Access to health services, which is considered in the measurement of multidimensional poverty, reflects the essential element of the right to health. Based on this criterion, the threshold for calculating this deprivation is the entitlement or right to receive medical services from a public institution or private services. Its components refer to the employed population without direct access to health services and the unemployed population without access to health services. In the state of Hidalgo, 43.5% of people without access to medical services were recorded in 2024, which means they use other alternatives such as private services or self-medication. [INEGI, Análisis de los resultados de la medición de la pobreza multidimensional, 2025].

Box 1

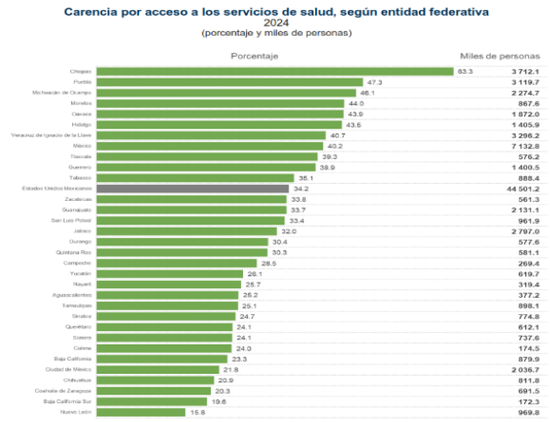


Figure 1

Lack of access to health services, by federal entity, 2024

Source: [INEGI, Carencia por acceso a los servicios de Salud, 2024]

The search for specialists is based on verbal recommendations, which often do not provide complete or up-to-date information on the availability and location of specialists. Likewise, the gap between rural and urban areas makes it even more difficult to access up-to-date information on specialists. There are no specialist clinics in the Huasteca region, so doctors from other urban areas such as Mexico City, Pachuca, Tampico, and other places are willing to see patients on certain days in Huejutla Hidalgo. However, these visits are sporadic.

Given the problem encountered, it is considered an area of opportunity to create a website with information on specialist doctors who attend in the region, with availability of dates and hours of attendance, to offer users a tool capable of concentrating this detailed and up-to-date information.

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First, the needs and problems of users were identified, which will define the requirements of the platform, by collecting information and conducting user studies, ensuring that the platform meets user expectations.

Subsequently, the characteristics and functionalities of the platform were defined, including its components and how they were developed. The elements necessary for the web platform to be simple and functional, requiring little maintenance and easy to navigate, were also analysed, implementing an intuitive and clean design with the aim of improving the user experience and reducing the maintenance workload.

Information and Communication Technologies are a crucial resource for strengthening health systems, integrating them into epidemiological surveillance, health promotion and care activities, under the concept of e-Health. This includes applications such as electronic health records, clinical decision support systems and telemedicine, among others.

1. Theoretical Foundations

2.1 Health: a constant concern

To achieve effective access to the right to health, there must be no barriers or obstacles to accessing services, whether physical, economic, or related to information about the location of health facilities and the problems they can address. Likewise, the availability of sufficient physical and human resources must be guaranteed, and efforts must be made to ensure that these resources have the best possible tools in terms of updating and training so that patients receive quality care as soon as they need it, that it is continuous and that it is also culturally appropriate and sensitive to gender and life course requirements. [CONEVAL, 2018]

Practising a healthy lifestyle has a positive effect on the functioning of the body and mind, as well as preventing chronic non-communicable diseases. Healthy habits can improve quality of life and prevent obesity, diabetes, cardiovascular and respiratory conditions. A combination of practices, such as exercising, getting enough rest and maintaining a varied and balanced diet, contributes to personal well-being.

The adequate location and distribution of medical specialists in a region is essential to ensuring an equitable and efficient health system that is capable of responding to the real needs of the population.

In rural or isolated regions, the lack of specialists often creates significant gaps in access, preventing rapid medical care.

Box 2

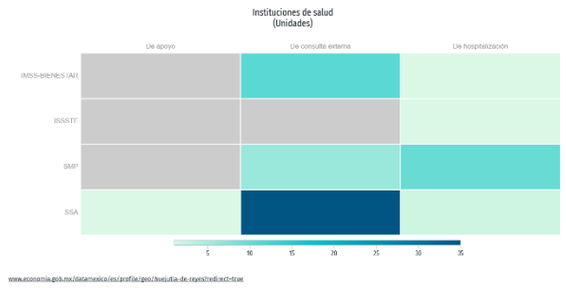

Figure 2

Health institutions [Units]

Source: [DataMéxico, Instituciones de_Salud, 2022]

The constant concern for health in Huejutla de Reyes Hidalgo and in all states is related to the death rate and causes, which is worrying and alarming for the population.
The presence of specialists is directly related to better health outcomes.

Regions with lower densities of specialists have higher rates of preventable mortality, untreated disabilities, and delayed diagnoses.

Box 3

5 principales causas de muerte, según entidad federativa de residencia habitual y sexo de la persona fallecida[1/]
2024

Hidalgo			
Rango	Total	Mujer	Hombre
1	Enfermedades del corazón 4 921	Enfermedades del corazón 2 337	Enfermedades del corazón 2 584
2	Diabetes *mellitus* 2 598	Diabetes *mellitus* 1 312	Diabetes *mellitus* 1 286
3	Tumores malignos 2 213	Tumores malignos 1 137	Tumores malignos 1 076
4	Enfermedades cerebrovasculares 1 003	Enfermedades cerebrovasculares 454	Accidentes 762
5	Accidentes 989	Enfermedades pulmonares obstructivas crónicas 266	Enfermedades del hígado 664

Figure 3

Top 5 causes of death, by federal entity of usual residence and sex of the deceased person

Source: [INEGI, 5 principales causas de muerte, según entidad, 2022]

2.2 Active participation of patients in their own care

Patient involvement in their own care is a fundamental pillar of Patient-Centred Care. This approach encourages patients to be active collaborators in decisions related to their health.

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It involves openly sharing information with healthcare professionals, making informed and joint decisions about treatment, and proactively managing their self-care. This participation empowers patients, making them feel responsible for their well-being and promoting a more equitable and satisfying relationship with their healthcare providers. [UNIR Universidad en Internet, 2023]

Patient involvement in the care process and decision-making not only improves clinical outcomes, but also patient satisfaction and perceived well-being during treatment. Participation involving dialogue and collaboration with professionals is associated with a better experience and positive perceptions of the care received. [Kim, 2018]

2.3 Impact of Technology on Rural Health

Public health plays a crucial role in improving the quality of life of the population through various strategies and actions focused on disease prevention, health promotion, and improvement of health systems.

The healthcare system in Mexico faces multiple challenges that affect both the accessibility and quality of medical services available to the population. One of the most pressing problems is the lack of physical and economic access for many citizens, especially those living in rural or marginalised areas. This translates into long distances to reach health centres and prohibitive costs for many.

In addition, hospital infrastructure has significant deficiencies, with most units concentrated in urban areas, leaving rural communities with limited coverage.

The availability of hospital beds is low compared to international standards, making it even more difficult to access timely medical care, especially in emergencies.

Medical personnel are also scarce, with an insufficient ratio of general practitioners and specialists per thousand inhabitants. This means that many people do not receive the necessary medical care at the right time, exacerbating health problems and increasing mortality rates from preventable diseases. In terms of quality, there are concerns about long waiting times in emergency rooms and the incidence of medical malpractice in the public sector.

This affects the population's confidence in the health system and compromises the effectiveness of treatments and care received. In addition, educational campaigns for disease prevention have not succeeded in significantly reducing the high rates of chronic diseases such as diabetes and obesity, which continue to be a major burden on the public health system. In response to these challenges, the Mexican government has outlined a strategic plan to improve the coverage, quality, and efficiency of the health system, focusing on increasing transparency in the use of resources, expanding infrastructure in underserved areas, and strengthening prevention and health education strategies.

This approach is crucial to ensuring that all Mexicans have equitable access to adequate health services and can receive quality medical care, regardless of their geographical location or economic situation. [García, 2019]

The digitisation of the health sector is essential in Mexico, with a growing emphasis on technologies such as telemedicine, remote monitoring, and artificial intelligence. These technologies are transforming healthcare by enabling remote communication between doctors and patients, as well as remote monitoring of critical conditions. This is especially beneficial for rural areas where physical access to hospitals is limited. However, it is crucial to establish clear regulations to ensure the safety and efficacy of these technologies, as well as to encourage innovation and collaboration between the private and public sectors to improve the quality and accessibility of healthcare in remote areas. [Asociación HealthTech México, 2023]

2.2 Accessibility to Specialised Healthcare

Access to health services, which is considered in the measurement of multidimensional poverty, reflects the essential element of the right to health. Based on this criterion, the threshold for calculating this deprivation is the entitlement or right to receive medical services from a public institution or private services. Its components refer to the employed population without direct access to health services and the unemployed population without access to health services.

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In 2024, the percentage of the population lacking access to health services was 34.2%, representing 44.5 million people. From 2016 to 2022, this deprivation increased from 15.6% to 39.1% of the population [a difference of 31.6 million more people]. However, between 2022 and 2024, there was a reduction of 4.9 percentage points, meaning that 5.9 million more people reported being affiliated, registered, or entitled to receive health services in a public or private institution.

Box 4

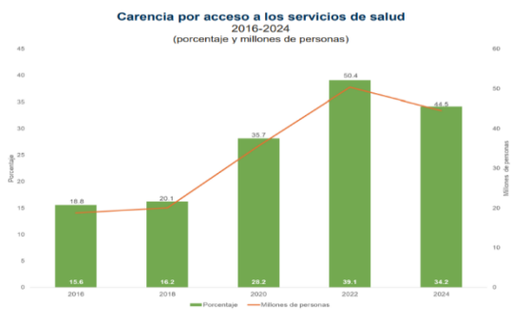

Figure 4

INEGI. National Household Income and Expenditure Survey [ENIGH] 2024, using the Coneval methodology.

Source: [INEGI, Carencia por acceso a servicios de Salud , 2024]

This is why the population has opted for another alternative for medical care that is available:

In 2024, the Health Statistics in Private Establishments [ESEP] integrated information from 2,747 establishments distributed across 558 municipalities and territorial districts. Of these, 63 had at least 10 private establishments and accounted for 56.1% of the total number of such establishments.

The states that accounted for 52.5% of private health establishments were as follows: State of Mexico, with 15.6%; Mexico City, with 8.3%; Jalisco, with 7.5%; Guanajuato, with 6.3%; Michoacán, with 5.1%; Veracruz, with 5.0%; and Puebla, with 4.7%. The following municipalities and territorial divisions had at least 20 establishments and, together, accounted for 33.3% of them: Tijuana, Guadalajara, Puebla, Nezahualcóyotl, Iztapalapa, Toluca, Ecatepec, Gustavo A. Madero, Morelia, Juárez, León, Cuauhtémoc, Monterrey, Naucalpan de Juárez, Cuernavaca, Acapulco de Juárez, Oaxaca de Juárez, Zapopan, Querétaro, San Luis Potosí, Tuxtla Gutiérrez, Durango, Benito Juárez, and Reynosa.

Box 5

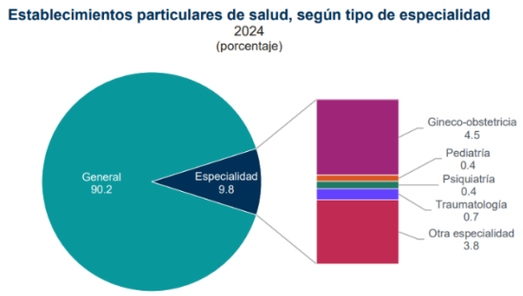

Figure 5

Health statistics in Private establishments [ESEP]

Source*:* [INEGI, ESEP, 2024]

These statistics show that there is no concentration of specialists in the Huasteca region and few in general hospitals.

The following information is available for Huejutla de Reyes Hidalgo.

Box 5

Table 1

Statistics on clinics and doctors

Centre / Unit	Consulting rooms	Total doctors	General practitioners	Medical specialists	
Huasteca General Hospital [SSA]	11	45	11	**13**	[hospitalesmexico.com]
Urban Consultation Unit [SSA]	6	22	15	**1**	[hospitalesmexico.com]
Tehuetlán Rural Unit [SSA]	3	6	4	**0**	[hospitalesmexico.com]
IMSS-Prospera Rural Hospital	15	39	8	**5**	[hospitalesmexico.com]
Private clinics [Doctoralia / directories]	—	Various	Various	- Several private specialists	[Doctoralia]

2.1 Challenges in accessing medical specialists

The main challenges in accessing medical specialists include a shortage of professionals, geographical and financial barriers, and long waiting lists. These problems are particularly acute in countries such as Mexico, where the distribution of doctors is uneven and resources are limited. These challenges can be grouped into**:**

- Uneven geographical distribution of specialist staff

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Specialists are concentrated in urban areas, working in large cities or hospital centres, while rural municipalities or those with a highly dispersed population have few or no specialists.

- Shortage of specialists in certain areas

In many health systems, there are specialities with chronic shortages [e.g. geriatrics, psychiatry, oncology, nephrology].

- Economic barriers

Even when specialists are available, access may be limited by: private consultation costs, travel expenses, costs of diagnostic tests and specialised medicines, and low availability of insurance or public coverage.

- Administrative barriers

In public or social security systems, access to a specialist may require: extensive paperwork, long waiting lists, limited hours and availability of appointments.

- Cultural and linguistic barriers

In indigenous regions or traditional rural communities: Lack of specialists who speak the local language.

2.1 Technologies to Improve Public Health

The impact of technology on rural health can be seen on several fronts: community radio stations are key to transmitting health and environmental messages in an accessible way; colourful billboards are used effectively to communicate public issues visually; community assemblies remain important even without direct technological mediation, depending on the tone of voice and status of the participants; and municipal presidencies still use traditional methods such as car-mounted loudspeakers. Broader integration of digital technologies could improve communication and emergency response in these rural communities. [Matus & Ramírez, 2020]

The digitisation of the health sector is essential in Mexico, with a growing emphasis on technologies such as telemedicine, remote monitoring, and artificial intelligence.

These technologies are transforming healthcare by enabling remote communication between doctors and patients, as well as remote monitoring of critical conditions. This is especially beneficial for rural areas where physical access to hospitals is limited. However, it is crucial to establish clear regulations to ensure the safety and efficacy of these technologies, as well as to encourage innovation and collaboration between the private and public sectors to improve the quality and accessibility of healthcare in remote areas.

3. Methodology

The XP methodology was chosen for this project because of its focus on simplicity, effective communication, and adaptability to change. XP promotes the frequent delivery of functional versions of the product, allowing for early feedback and adjustments to development accordingly. In addition, the XP methodology encourages collaboration among team members and continuous improvement of the product, leading to a more successful launch and customer satisfaction.

Extreme Programming [XP] is an agile methodology proposed in 1999 by Kent Beck in his book entitled 'eXtreme Programming eXplained' for the development of IT projects, which seeks to solve the problems encountered in the creation of software engineering projects. It is used for short-term projects, small development teams, and projects with relatively short delivery times, presented to the user in the form of small deliverables, whose goals and schedules are adjusted in real time according to the level of progress and the actual difficulties presented by the project.

Box 6

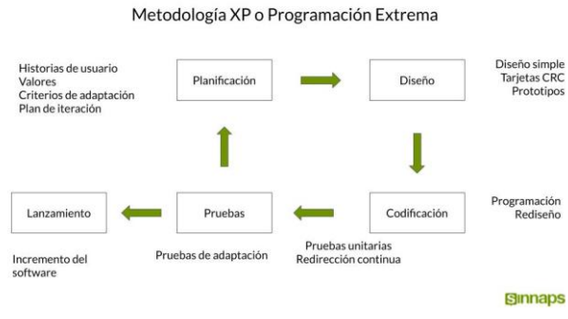

Figure 6

Extreme Programming [XP] Methodology

Source: [Calderón & Valverde Rebaza, 2007]

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3.1 Planning.

1 During this phase, a meeting was held between the stakeholders, i.e. the developer and the client, to identify the project requirements. Priorities were established, identifying the problem, the objective and the justification for why the website, named 'DoctorHelp', should be developed. The client stated the desired modules and their purpose, providing a clear vision of the needs and functionalities.

2 Records were drawn up describing the desired characteristics of the website from the end user's perspective. These records were used in the following phases. Planning includes estimating the effort required to complete each requirement, which helps to define the scope and time required. For this reason, a schedule of activities was drawn up, and the optimal methodology for the type of project was chosen, in this case the XP methodology.

3 In each phase of this methodology, we planned how and when the client's requirements would be completed, organising the schedule by weeks. Each week was dedicated to a specific task, ensuring that the time spent on creating the website was distributed efficiently. This weekly approach allowed the developer to focus on clear and achievable goals, maintaining a steady pace of progress. It also facilitated the early identification of problems and the implementation of necessary adjustments, ensuring that the project remained aligned with the client's expectations and the established deadlines.

Thus, the development of the website was carried out in a structured and organised manner, optimising the use of time and available resources.

Box 7

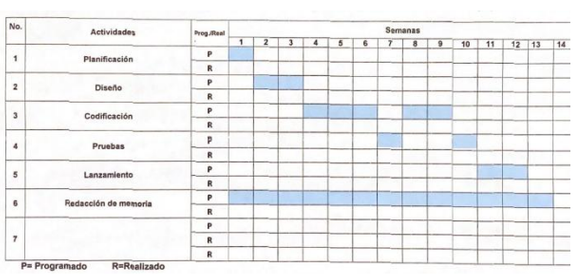

Figure 7
Planning

Source: Own work

3.2 Design

At this stage, the website architecture was created, including the navigation map, data model, and interface. The focus was on simplicity and clarity to ensure an optimal user experience. Within this architecture, the navigation map was added, which was designed in several ways to select the most efficient and user-friendly option for the user.

The number of clicks required for users to quickly access a catalogue was considered, thus optimising navigation and improving the usability of the website.

Box 8

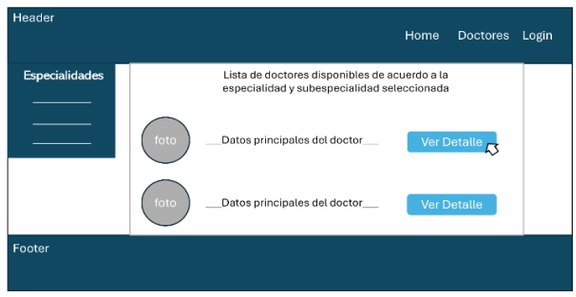

Figure 8
Interface Design

Source: Own work

The data model was designed, structuring how the data necessary for the website to function would be stored and managed. A robust and well-organised database was created, allowing for efficient data access and manipulation. In addition, the website interface was designed with a focus on providing an attractive visual experience and intuitive navigation. Colours, fonts and visual elements were carefully selected to create a professional appearance consistent with the DoctorHelp identity. Several prototypes of the interface were developed, testing different layouts and styles until the combination that best suited the needs of the client and end users was found.

Box 9

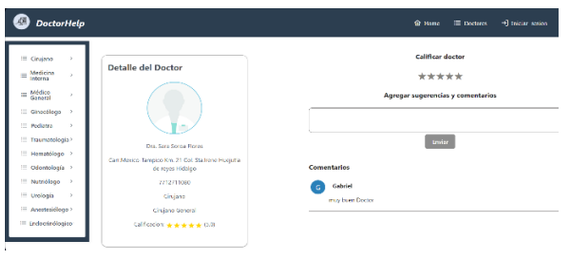

Figure 9
Final site design

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Del Carmen-Morales, Heidi, Del Carmen-Morales, Yucels Anaí, Felipe-Redondo, Ana María and Hernández-Rodríguez, Yvan de Jesús. [2025]. Website of medical specialties of the region Huasteca Hidalguense. Journal Applied Computing. 9[23]1-11: e7923111.
https://doi.org/10.35429/JAC.2025.9.23.7.1.11

Attention to detail in the design phase ensured that the website not only met functional requirements but also provided a smooth and enjoyable user experience. The well-planned architecture and carefully designed interface laid the foundation for successful development, allowing the developer to move confidently on to the next phase of the project.

3.3 Coding

In this phase, the coding of the website began. The project was created in Visual Studio Code, using TypeScript and Vite, technologies that provide a solid and efficient foundation for frontend development. For data management, a database was designed and created in MongoDB, with local testing to ensure proper functioning and optimise performance. Subsequently, a proprietary API was developed for the backend, which was responsible for managing interactions with the database and providing the services necessary for the website's functionalities.

Special attention was paid to the user interface, refining the details to provide an attractive visual experience consistent with the DoctorHelp identity. This included the careful selection of colours, fonts and graphic elements, as well as optimising the layout of the components on the page to facilitate navigation.

3.4 Testing

In this phase, exhaustive testing was carried out on the system to ensure that the DoctorHelp website offered the best possible experience to users. Various unit tests were carried out to verify that each individual component was functioning correctly. Some of the tests carried out are detailed below.

Test carried out: Verify that the `BannerPrincipal` component is rendered correctly.

Result: Test passed.

In addition, integration tests were run to ensure that all components worked together without conflicts. Real-world usage scenarios were simulated to verify that key functionalities, such as searching for doctors, viewing profiles, and booking appointments, worked smoothly.

- Test performed: Verify that `CarruselDoctores` loads the list of doctors and displays correctly on `Home`.

Result: Test passed.

Performance testing was also an essential part of this phase.

The speed and responsiveness of the website was evaluated under different user loads, ensuring that it could handle traffic spikes without degrading the user experience. Additional security measures, such as data encryption and robust authentication, were implemented to protect the privacy and integrity of user data.

- Test performed: Evaluate the responsiveness of the doctor carousel under different user loads.

Result: The page maintains a fast response even with 100 simultaneous users.

In addition to technical testing, usability tests were conducted with real users to obtain direct feedback on the browsing experience and interaction with the website. These users provided valuable insights on aspects such as ease of use, interface clarity, and overall satisfaction with the system's functionality. Based on their feedback, adjustments and improvements were made to ensure that DoctorHelp was intuitive and easy to use for everyone.

3.5 Launch

This phase saw the launch of the ‘DoctorHelp’ website, marking the culmination of months of planning, design, development, and rigorous testing. In addition, all monitoring systems were ensured to be operational, providing real-time data on the performance and stability of the website.

4. Results

An interactive website was developed to meet the needs of users searching for information on medical specialists in Huejutla de Reyes, Hidalgo. Advanced technologies were employed to ensure that the platform was efficient, easy to use, and capable of solving the identified problems.

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A detailed exploration was carried out in which theoretical research supported the need found in Huejutla de Reyes, Hidalgo. First, user needs were identified, which defined the platform's requirements. Through information gathering and user studies, a detailed report analysing user needs was obtained.

This process was crucial to ensure that the platform met user expectations, ensuring that all essential functionalities were aligned with their needs.

Subsequently, the XP methodology that would monitor the project was defined, and a clear structure was developed detailing the aspects that make up the platform and how each functionality should operate to meet the requirements of end users. This phase allowed us to structure a system that responds directly to user demands, ensuring their satisfaction and usefulness.

An intuitive and clean design was also implemented to improve the user experience and minimise the maintenance workload, resulting in an interface that facilitates navigation and allows for efficient interaction with the system.

After writing the project code in accordance with the established requirements and following best programming practices, we ensured that the system worked correctly and offered an optimal user experience. In addition, we conducted exhaustive testing of the system's functionality, performance, and usability, ensuring that the system operated smoothly and provided a positive user experience. These tests helped identify and resolve potential issues prior to launch.

Finally, the final version of the product was prepared, functional, ready and accessible to users. The results obtained confirmed that the approach used to develop the platform was effective, significantly improving access to specialised medical information.

The well-defined structure of the platform and the intuitive design provided an enhanced user experience, demonstrating that the technologies employed are suitable for this type of project.

Box 10

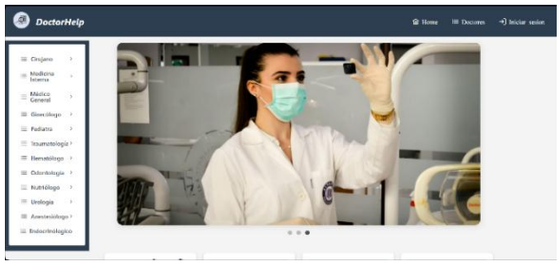

Figure 10

Final site design.

Source: Own work

5. Conclusions

The main objective of this project was to develop an interactive digital platform called DoctorHelp, designed to improve access to information about medical specialists in Huejutla de Reyes, Hidalgo. Using advanced technologies such as Vite, React, TypeScript, MongoDB, and Node.js, we were able to create a robust, scalable, and easy-to-maintain solution. These tools not only ensured that the platform was fast and secure, but also provided an optimised user experience, significantly reducing the time and effort required to find specialised medical information.

All specific objectives were met. A comprehensive analysis of user needs was carried out through information gathering and user studies, which allowed us to define clear and precise requirements for the platform. Features and functionalities were established in line with end-user expectations.

In addition, an intuitive and clean interface was designed, which significantly improved the user experience and made it easier to navigate the system. The code was implemented following best practices and extensive testing was carried out to ensure that all the system's functionalities were working correctly.

The expected impact of DoctorHelp is significant because, by centralising and constantly updating information on medical specialists, the platform will facilitate access to health services for the population of Huejutla de Reyes.

The platform is expected to reduce barriers to accessing specialised medical care, particularly in rural areas, and contribute to better local public health management.

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In a second stage, the aim is to keep the platform regularly updated to ensure its continued relevance, involve users in the evaluation of new functionalities, and seek opportunities to integrate new technologies that can further improve the user experience. In addition, it is suggested that partnerships be established with local medical institutions to ensure that the information provided is always accurate and up to date, thus maximising the positive impact of the platform on the community.

During the launch, a communication campaign was carried out to inform the community of Huejutla de Reyes, Hidalgo about the availability of 'DoctorHelp'. Various channels were used, including social media, emails, and local advertisements, to ensure that the news reached as many people as possible.

The campaign emphasised the features and benefits of the website, highlighting how DoctorHelp would facilitate access to medical specialists in the region. Data was collected from doctors to make it available on the website.

The launch of DoctorHelp was a meticulous and well-planned process, designed to ensure a positive experience for users from the outset. The combination of a gradual rollout, an effective communication campaign, adequate technical support, and constant monitoring ensured that the website established itself as a reliable and valuable tool for the community of Huejutla de Reyes, Hidalgo.

Declarations

Conflict of interest

The authors who belong to the Academic Body in Information Technology [CATI] declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article.

Contribution of the authors

Del Carmen Morales, Heidi: Contributed the research idea and project management, performing the role of coach and developer.

Del Carmen-Morales, Yucels Anaí: Participated in the design phase, performing the role of tracker.

Felipe-Redondo, Ana María: Participated in defining the technologies to be used and took on the role of developer.

Hernandez-Rodriguez, Yvan de Jesus: An expert server engineer working in the industry, he guided the team and took on the role of tester.

Availability of data and materials

The data, results and information collected are available for consultation upon request to the corresponding author.

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Abbreviations

XP	Extreme Programming XP
XP	Extreme Programming
SNS	National Health System
UNIR	Internet University
INEGI	National Institute of Statistics and Geography
CATI	Academic Body in Information Technology
CONEVAL	National Council for the Evaluation of Social Development Policy
CI	Continuous Integration
TIC	Information and Communication Technologies
UTHH	Technological University of the Huasteca Hidalguense

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Background

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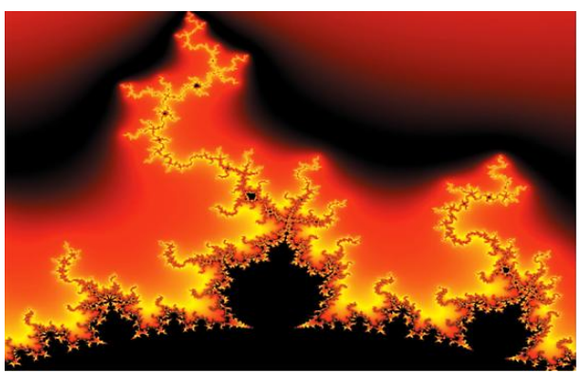

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