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Presentation of the Content

In the first article we present, *Defect injection prevention in Software development: An Introspection into Historical Projects carried out at Software Factory TecNM: Zacatecas Sur* by GONZÁLEZ-RADILLA, Ma. Estrellita, CAMPA-GARCÍA, Rafael and LUNA-AYALA, Luz Elvira, with adscription in the TECNM: Zacatecas Sur, as the next article we present, *Artificial Intelligence as a tool for analyzing cognitive and thinking problems: Rubik's Cube* by HERNÁNDEZ-CRUZ, Luz María, UC-VAZQUEZ, Diana Carolina, ORTIZ-CUEVAS, Nancy Georgina and PANTÍ-GONZÁLEZ, Daniel Alberto, with adscription in the Universidad Autónoma de Campeche, as the next article we present, *Bibliometric Analysis of Smart Parking* by ROJAS-SOTO, Irving Alan Ramón, CEDILLO-ELIAS, Elsa Julieta, GÓMEZ-BARBA, Leopoldo and ORIZAGA-TREJO, José Antonio, with adscription in the Universidad de Guadalajara, as the next article we present, *Exploratory-descriptive study of the most widely used programming languages in the software industry in Mexico. An educational approach* by SOLÍS-CARDOZA, Víctor, JARA-FLORES, Junior, MORENO-HERNANDEZ, Azucena and TORRES-BECERRA, Jesús, with adscription in the Universidad Autónoma de Coahuila and Universidad Tecnológica de la Laguna de Durango.

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Defect injection prevention in Software development: An Introspection into Historical Projects carried out at Software Factory TecNM: Zacatecas Sur

Prevención de inyección de defectos en el desarrollo de Software: Una Introspección a Proyectos Históricos realizados en la Fábrica de Software TecNM: Zacatecas Sur

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Abstract

Around software development, there are many variables, which provide support for calculating different quality factors or simply for keeping historical data and learning lessons from previous developments; from these data, decisions can be made to improve the activities carried out in processes and in development methodologies. The aim of this research is to gather and analyze the defects identified by the development team during the inspections they conduct in the testing phase, in order to prevent the same defects in future developments. Additionally, it involves analyzing the impact that timely detection has on time and forming high-performance development teams. Starting from the system development using web-based programming technologies for users, defects encountered during the development process are collected and consolidated into a template based on the ISO 29110 standard. This template is adapted to work with small software development entities, particularly in the Software Project Implementation process. The most significant contribution lies in raising awareness about defect prevention through the induction provided to software project collaborators.

Defects, Development, Implementation

Resumen

En torno al desarrollo de software existen muchas variables, las cuales son de apoyo para el cálculo de diferentes factores de calidad o simplemente para llevar datos históricos, y tener lecciones aprendidas de desarrollos previos; a partir de estos datos se pueden tomar decisiones en la mejora de las actividades realizadas en los procesos y en las metodologías de desarrollo. El objetivo de esta investigación es recopilar y analizar los defectos encontrados por el equipo de desarrollo en las inspecciones que realizan en la etapa de pruebas, para prevenir en futuros desarrollos los mismos defectos, y hacer un análisis del impacto que tiene en el tiempo, la detección oportuna para conformar equipos de desarrollo de alto rendimiento. A partir del desarrollo del sistema con tecnologías de programación para usuarios en la web, se recopilan los defectos encontrados durante el desarrollo y se concentran en una plantilla basada en la norma de ISO 29110, la cual esta adaptada para trabajar con pequeñas entidades de desarrollo de software, específicamente en el proceso de Implementación de proyectos de Software. La contribución más importante es la concientización en la prevención de defectos, en la inducción que se ofrezca a los colaboradores de proyectos de software.

Defectos, Desarrollo, Implementación

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Introduction

Software Engineering is a relatively new field, and unlike other sciences, it has reached high levels of knowledge generation. To develop software, various methodologies and tools are used, all following a dynamic that begins with a future idea of requirements and ends with the implementation of the idea into a functional product. Throughout this development process, a satisfactory level for the end user must be achieved. In this context, software quality must be present in every phase of its conception, ensuring that it operates according to established standards.

One of the objectives of this research is to precisely identify, during the development stage, the severity, priority, and types of anomalies with which the software is coded. With this data, common inserted defects can be analyzed to generate knowledge for defect prevention in future projects.

Currently, most of the information systems we use have undergone a process of improvement, gradually refining and adapting their solution to the problem for which they were developed. In this case, the aim is to minimize the time it takes to identify development errors by focusing on the development experiences of other systems.

Thus, it is assumed that the most common defects in software development are logic-related with high severity and significant impact, given the time required for correction. This article is structured to provide the reader with a general overview of the research process followed, starting with the justification, the problem under investigation, and a hypothesis.

From these references, the methodology used for analyzing the information is immediately presented, considering the historical data from the database that has been accumulating during the software development process. Once finished, some of the obtained results are shown, contrasting them with the objectives, and finally, the findings are mentioned at the end.

Justification

The Tecnológico Nacional de México has 254 institutions throughout the country, serving a student population of over 600,000 in undergraduate and postgraduate programs across the national territory, including Mexico City, (H. Bravo, d. I. Cruz, C. Gómez, Montero, & V. Carrillo, 2022) One of these institutes is the Zacatecas Sur Campus, located in a municipality very close to Guadalajara City, Jalisco. Guadalajara is considered a hub of development in information and communication technologies.

Thanks to this location, a software factory was established within the Institute's facilities, operating with the talent of students in the Bachelor's degree program in Computer Systems Engineering who have completed their fifth semester. These students, equipped with their prior professional competencies, are assigned projects for the productive sector of the region. However, it has been observed that when reaching the testing phase, numerous defects are identified by the development team. As it is known, each defect entails time for correction.

In our commitment to quality, the software factory TecNM: Zacatecas Sur, has been certified with the ISO/IEC 29110 standard. This certification enables us to address defects by documenting them in a test report format. Defects are categorized by severity, priority, and anomaly type. A brief explanation of the findings is provided, and the report is then returned to the development team for correction. This document keeps track of the identified defects and the manner in which each anomaly was resolved.

With this information, our aim is to conduct an analysis of these defects, classify and validate them using theoretical elements. The objective is to share these results with future development teams so that they can consider them when initiating another project. This knowledge could potentially help prevent historical defects from occurring again.

Problem

When developing software, project planning is carried out, which involves estimating the project cost, the expected time, and establishing the metrics that will be followed during the process.

However, during development, significant delays can occur due to the injection of logical defects, which increases the budget, affects quality, and extends the estimated time. Keeping track of these defects limits and disrupts the progress of the project.

Hypothesis

Most of the defects in software development are related to functionality and are inserted during the coding stage. These defects have a significant impact on project planning, causing delays for the team in their tasks due to the time required for correction.

Methodology

Developing software is a seemingly simple task from the perspective of code generation. Tools designed for such tasks can be utilized, or one can rely on a high-level programming language. If we assume that even individuals with limited knowledge of computers or information technologies, through watching videos or tutorials, can code and produce a functional product.

However, even if these products are functional, they might lack methodological foundation, and we could conclude that they lack quality. Hence, developing quality software must not be considered an easy task. Prior knowledge, technical skills, and understanding of theoretical-conceptual models, architectures, and ways to structure software requirements into functionalities are required. This should be done while adhering to trustworthy parameters that solve the problem for which they were developed.

When working with small teams or companies with few employees, it is possible to develop a high-quality software system by following structured models that provide guidelines ensuring the product meets proposed standards along with established functional requirements. These can be validated and verified by the end user. In this case, the standard ISO/IEC 29110 (Anaconda, Pino, Buitrón, Rodríguez, & Piattini, 2020) This is a series of standards for Software Engineering that provides a framework for small organizations.

This standard is followed as a reference framework in the TecNM: Zacatecas Sur software factory, as its objective is to enhance the quality of software development projects for very small entities. In this factory, two or three projects are developed per year. To form development teams, an academic meeting is held where teams are composed of students based on requests received by the software factory. The main advisor and two or three collaborators are then assigned, and the software project is authorized for execution.

Once the project is authorized, it is important to adhere to the stages required by the standard. One of these stages is Project Management, which includes:

- Project planning.
- Project execution.
- Project evaluation and control.
- Project closure.

In the second phase known as Software Implementation, the following is required:

- Software requirements analysis.
- Software architecture and detailed design.
- Software construction.
- Software integration and testing.
- Product delivery.

This research focuses on the second phase, specifically on the point of software integration and testing, as validations are conducted with the aim of aiding in the reduction of defects in applications and achieving early identification before integration. (Mera-Paz, 2016).

In the development of each project, a repository is maintained to have control over the documentation and evidence of each activity carried out. This repository includes:

1. Planner.
2. Requirement specification.
3. Software configuration.
4. Testing.
5. Tracking.
6. Manuals.

The testing folder contains a document where information about the found defects and evidence of them is gathered. It's worth noting that testing follows a process involving the following activities, starting from planning and control, selecting test conditions, designing and executing test cases, verifying results, evaluating result criteria, as well as preparing process reports and the application of the tests, including experience logs.

We understand that conducting tests is a highly important tool for identifying defects. However, it doesn't guarantee the absence of hidden defects in the software. This is why the absence of detected defects doesn't serve as evidence that the software is entirely correct. We acknowledge that thoroughly testing everything from end to end, covering all inputs and conditions, is extremely difficult, some might even say impossible. (Kuhn, Gallo, & Wallace, 2004)

(Ciolkowski, Laitenberger, & Biffli, 2003) Review is defined as an approach for examining software products for defects or deviations from established standards and other issues.

There are also process tools that support work in an efficient and organized manner, such as Kanban, proposed in 2004 by David Anderson. Kanban is a project management framework based on tasks for controlling workflow. The Scrum methodology is another project management framework that supports teamwork by structuring and managing work through a set of values, principles, and practices.

(Faniran, Badru, & Ajayi, 2017) Tracking based on agile methodologies like Kanban and Scrum is used in the projects of the factory, as it allows breaking down the entire project into small deliverable functionalities for the client.

With these frameworks, early tests can be conducted to identify defects in each sprint and in the template designed for this purpose. After completing each stage of software development, starting from sprint planning, user stories are developed. These user stories specify the type of functional or non-functional requirement in a more detailed manner. These user stories include acceptance criteria, expected outcomes, and, crucially for this research, acceptance tests.

Once the user stories are finished, development or programming takes place, adhering to standards and database creation. During the testing phase, test cases are executed, and each case is documented in a template that outlines the test case design, specifying for each one:

- Folio.
- Short name.
- Detailed description.
- User story.
- Prerequisites.
- Steps to perform.
- Expected results.
- Test status.
- Person responsible for the test.
- Findings.
- Observations.

Upon completing the sprint and when delivering to the client, another document is filled out for acceptance testing, which includes: the project name, leader, sprint, delivery date, and each of the functional requirements specifying whether they are approved, not approved, and any observations.

There is another document called unit tests, which is a format that is completed as follows: For each software component (module or class), the following information should be provided: Module name, description of each action to be verified, name of the method to be tested, input data to be used, expected output of each step's execution, and results (ok, date, observations) filled in after tests are executed, thus obtaining the Unit Testing Results Report.

Once a part of the development process followed in the factory is disclosed, an important template for this research comes into play: the test report, an essential part that aids in the collection and analysis of defects found by the team members responsible for testing. The information it contains is as follows:

- Folio.
- Person in charge of testing.
- Defect status.
- Report date.
- Short name.
- Detailed description.
- Reproduction steps.
- Evidence file.

- Severity.
- Priority.
- Anomaly type.
- Developer's comments.
- Test comments.

For the purposes of this research, we focus on the defects found and recorded in the corresponding fields of severity, priority, and anomaly type. Starting with the severity of the defect, as shown in Table 1, a range from 1 to 5 is used, with the first being very high, the second high, the third moderate, the fourth low, and the last enhancement. It is also focused on the user experience with the project, which students in the testing role assess based on their knowledge of the project. However, assigning priority is more challenging, as will be explained further.

Severities	
1. Very High	The component cannot be used or blocks the test and operation. It is not possible to continue the test. There is no alternative solution to proceed with the test.
2. High	Critical functions are affected without the possibility of performing them differently, and this affects a considerable number of test cases.
3. Average	Functions are performed incorrectly by the system. The component can be used but with restrictions, there is an alternative solution.
4. Low	They refer to the appearance of the system or cause inconveniences and annoyances to users, without the system being significantly affected in terms of functionality. These are cosmetic improvements that can be resolved or deferred to a new version.
5. Improvement	It does not represent an anomaly as such from a critical point of view, as it is not associated with a specific requirement, but it is a proposal to improve the system.

Table 1 Defect Severity
Source: Own Elaboration

For each defect, it is necessary to classify it according to a priority. Table 2 shows the way in which the resolution priority of the defect should be given, with a range from 1 to 4, where the first is immediate, second is important, third is average, and the last is low. As mentioned earlier, assigning priority is more challenging since severity is related to the impact of a defect occurring, while priority is determined by the business and is related to the urgency of resolution.

It is assigned by the student in the role of leader or by the client, and it can change throughout the project's lifecycle.

Priority	
1. Immediate	Resolve immediately, as soon as it is reported.
2. Important	Give high attention. It can be resolved in the next internal release.
3. Average	Normal attention. Resolve at least before delivering to the client.
4. Low	Low Priority. Desirable to be fixed before delivering to the client.

Table 2 The priority for defect resolution
Source. Own creation.

Next, the anomaly type must be recorded. Table 3 displays each of the potential types, some of which pertain to image, design, validation, functionality, unexpected termination, integrity, security, inaccurate calculation, system integration, and system help. Each type is represented by the initial letter of the anomaly category. Testers assign this classification based on their knowledge of testing concepts, specifically the anomaly type.

Anomaly type	
I. Image	It refers to errors in language, spelling, images, writing, etc.
D. Design	It means that the same standard is not followed across different functionalities and screens of the system
V. Validation	Verifies the information entered by the user in the system, such as data types, ranges, formats (RFC, postal codes).
F. Functionality	These are anomalies related to the system not meeting the specification of the requirement, meaning it doesn't perform the functions it was created for or doesn't perform them adequately (for example: calculation, deletion, generation, import).
T. Unexpected Termination	It indicates that for some reason, the system was terminated without the user intending to do so, for example, the system crashes (collapses), freezes, etc.
G. Integrity	When the data is not entirely reliable, they do not work properly together, for example, if a record is created in one module, the same information should be usable in a catalog or any other module.
S. Security	Issues related to not having data protected in an application, problems of confidentiality, authentication, system availability, or known vulnerabilities such as ease of access to intruders, among others.
C. Inexact Calculation	Issues related to problems in arithmetic operations.
IS. Systems Integrations	Issues in the interaction of one system with another.
A. Support Systems	When the information content in the system's help is incomplete.

Table 3 Type of Defect Anomaly
Source: Own Elaboration

The data collection was carried out from previously conducted projects related to web systems, where the total number of defects is 206, which were used in this research.

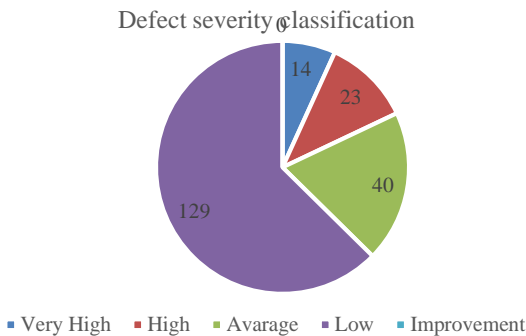
Results

One of the purposes of the research is to anticipate the injection of defects in the development stage, in such a way that the defects found were recorded in inspections. This means that no author inspects their own code or functionality. Therefore, these data serve as a source to predict the ongoing exposure to failure in future developments.

For the data analysis, the defects from the research sample were consolidated into an electronic spreadsheet. Subsequently, data segmentations were created, and it was decided to classify the information based on the way defects are recorded in the test report template. This approach was chosen because applying filters based on the presented categories would make it easier to perform the analysis of the information.

The first segment was based on the severity categories, where the information was filtered for each of the severities shown in the Table 1.

According to the severity classification, the results are displayed in Graph 1. The highest number of defects in this category were those categorized as "low," meaning that functionality is not significantly affected. Common defects in this category include spelling mistakes, interface arrangement, oversized text boxes, and excessive spacing between interface components.



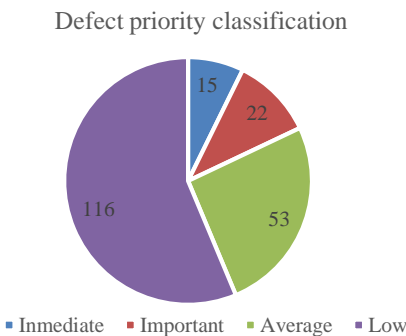
Graph 1 Defect Severity
Source: Own Elaboration

An example of high severity defects is shown in Figure 1. It pertains to the modification of an employee within the company. In the previous screen, the employee to be modified was supposed to be selected. On this screen, all fields should be populated with the employee's data for modification. However, as can be observed, the text boxes are empty, lacking any reference data for the modification process.



Figure 1 High Severity Defect
Source: Own Elaboration

Regarding the classification by priorities, which is based on the time required to resolve the identified defects, as shown in Graph 2, those demanding swift attention are evident. According to the results, these cases are few and, to some extent, provide a sense of assurance in the project's development. They do not require immediate resolution, and this aligns with the severity classification. As these defects are categorized as having low severity, their priority for correction is also low.



Graph 2 Defect Priority
Source: Own Elaboration

Due to the low priority of the defects, and in accordance with the definition outlined in Table 2 for defect resolution priority, it is desirable to address these issues before delivering the product to the client. It's worth mentioning that this is the workflow followed with the development teams. Tasks are assigned to each team member, and upon completion, the sprint's functionality is integrated. Subsequently, the responsible testing personnel are assigned to carry out product inspections.

They fill out the test report and share the findings with the authors. Once the inspections are completed, the authors proceed to rectify the identified defects, and these corrections must be completed before the product is delivered to the client.

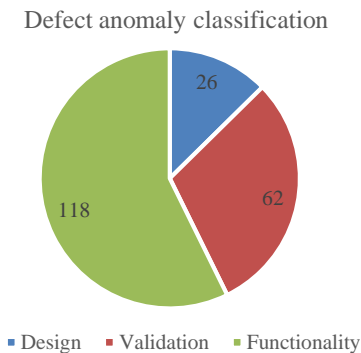
When the process of defect correction begins, development teams start with the ones that have immediate priority, as these have a more pronounced impact on the project. The advantage of this approach is that the defects falling into this category are not numerous when compared to the overall total.

The Figure 2 displays a defect with an average priority. In the phone number field of an interface, there is a flaw that allows letters and various types of characters to be input, even though it should ideally accept only 10 digits in reality.



Figure 2 Medium Priority Defect
Source: Own Elaboration

During the analysis of defects based on the type of anomalies shown in Graph 3, the category of functionality predominated. The most recurring defects within this category were non-functional links, issues with basic database operations such as saving, deleting, querying, or modifying, as well as misinterpretations of requirements by programmers.



Graph 3 Defect Anomaly
Source: Own Elaboration

Figure 3 presents an example of a functionality defect. At the interface level, the quantity of products for an order is input, but upon checking the database, it becomes evident that this quantity is not being stored correctly. The defect is noticeable in the "quantity" column, which displays a value of zero.



Figure 3. Database Functionality Defect
Source: Own Elaboration

Regarding defects classified under the validation anomaly, the most frequent ones were related to data types. These involved validations for numeric fields to ensure they do not accept letters or special characters, enforcing restrictions on the lengths of text boxes, and preventing the input of negative numbers in certain numeric fields.

A defect encountered in one of the projects was related to the "course duration" field. The client's requirement was to allow only four digits in this field. Figure 4 illustrates how the field accepted more digits than requested, indicating that the restriction was not properly implemented.

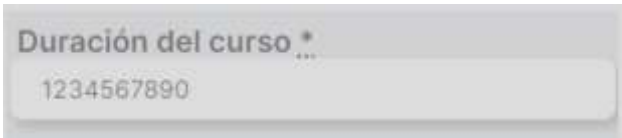


Figure 4. Validation Defect
Source: Own Elaboration

In this regard, it can be asserted that most of the defects shown here were identified during inspections. This emphasizes a key point in the results: the creation of a checklist for the most common defects found. This checklist should be completed during personal reviews, meaning that before passing the work product to a colleague or team members, authors should review it thoroughly to identify as many defects as possible before it goes through inspections.

Conclusions

Upon analyzing the results, the hypothesis put forth was validated: the highest number of defects by anomalies are related to functionality. These defects require significant time for correction, which, if not carefully managed, could lead to delays in client deliveries according to the overall project schedule. In upcoming projects, recording the time dedicated to resolving issues is anticipated to shed light on the impact within the broader project planning.

The aspect of the hypothesis referring to delays in task completion by team members has indeed been confirmed. Once the project is integrated and moves into the testing phase, it consistently requires intensive work with the development team to address defects discovered. This often necessitates working two days or more ahead of schedule, which results in project delays.

As part of the lessons learned from this research, several strategies are being considered for implementation in order to reduce the occurrence of defects. These strategies are outlined below:

- Checklists with the most common defects inserted according to their severity, priority, and type of anomalies.
- Implement automated testing.
- Personal reviews.
- Peer reviews.

Upon conducting this research, it becomes evident how development teams fare in terms of defect insertion. Now, it remains to implement the mentioned strategies and analyze if they yield the expected results – a reduction in defects during the testing phase. This, in turn, would impact the project timeline, leading to on-time deliveries in accordance with the planned schedule.

References

Ciolkowski, M., Laitenberger, O., & Biffl, S. (2003, Nov). *Software reviews, the state of the practice*. Retrieved April 2023, from IEEE Software, vol. 20, no. 6, pp. 46-51, doi: 10.1109/MS.2003.1241366.:
<https://ieeexplore.ieee.org/document/1241366>

Anaconda, A. F., Pino, F. J., Buitrón, S. L., Rodríguez, M., & Piattini, M. (2020, June). *Esquema de certificación por conformidad de requisitos del estándar ISO/IEC 29110 para la calidad de las empresas software*. Retrieved May 2023, from 2020 15th Iberian Conference on Information Systems and Technologies (CISTI), Seville, Spain, 2020, pp. 1-6, doi: 10.23919/CISTI49556.2020.9141029.:
<https://ieeexplore.ieee.org/document/9141029>

Faniran, V. T., Badru, A., & Ajayi, N. (2017, July). *Adopting Scrum as an Agile approach in distributed software development: A review of literature*. Retrieved June 2023, from 2017 1st International Conference on Next Generation Computing Applications (NextComp), Mauritius, 2017, pp. 36-40, doi: 10.1109/NEXTCOMP.2017.8016173.:
<https://ieeexplore.ieee.org/document/8016173>

H. Bravo, J. M., d. I. Cruz, E., C. Gómez, J., Montero, J. A., & V. Carrillo, Y. (2022, Oct). *Proposal of a Web System for information control of the engineering accreditation process of the Instituto Tecnológico Nacional de México campus Acapulco*. Retrieved April 2023, from 2022 11th International Conference On Software Process Improvement (CIMPS), Acapulco, Guerrero, Mexico, 2022, pp. 195-201, doi: 10.1109/CIMPS57786.2022.10035701.:
<https://ieeexplore.ieee.org/document/10035701/metrics#metrics>

Kuhn, D., Gallo, A., & Wallace, D. (2004, Jun). *Software Fault Interactions and Implications for Software Tes-ting*. Retrieved May 2023, from IEEE Transactions On Software Engineering, Vol. 30, no. 6, pp. 418-421 doi: 10.1109/TSE.2004.24:
<https://doi.ieeecomputersociety.org/10.1109/TSE.2004.24>

Mera-Paz. (2016, Oct). *Análisis del proceso de pruebas de calidad de software*. Retrieved June 2023, from Ingeniería Solidaria, Vol, 12, no. 20, pp. 163-176, doi: 10.16925/in.v12i20.1482:
<http://dx.doi.org/10.16925/in.v12i20.1482>

Artificial Intelligence as a tool for analyzing cognitive and thinking problems:
Rubik's Cube

La Inteligencia Artificial como herramienta de análisis de problemas cognitivos y de
pensamiento: El Cubo de Rubik

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Abstract

There is a wide variety of artificial intelligence (AI) algorithms today. The use of these algorithms can be carried out in different areas or fields of action, in turn, with different levels of efficiency. The objective of this article is to carry out an analysis of the impact of artificial intelligence algorithms and the various implementation mechanisms that can be used specifically in problem solving. The study proposes a documentary investigation, exhibiting a problem-solving case study known as Rubik's Cube, which is a mechanical puzzle that requires logical and spatial thinking skills. It is demonstrated that the application of AI algorithms is successfully used to reach a faster and more efficient resolution of the aforementioned puzzle, and that teaching its resolution contributes to the development of cognitive and logical thinking skills in students. It is expected that this contribution to the academic-scientific society will generate a new line of research in the development of cognitive skills and logical thinking with the use of AI to solve various problems in any area.

Resumen

Existe una gran variedad de algoritmos de inteligencia artificial (IA) en la actualidad. La utilización de estos algoritmos puede llevarse a cabo en distintos ámbitos o campos de acción, a su vez, con diferentes niveles de eficiencia. El objetivo del presente artículo es realizar un análisis del impacto de los algoritmos de inteligencia artificial y los diversos mecanismos de implementación que pueden utilizarse específicamente en la resolución de problemas. El estudio plantea una investigación documental, exhibiendo un caso de estudio de resolución de problemas conocido como Cubo de Rubik, el cual, es un rompecabezas mecánico que requiere de habilidades de pensamiento lógico y espacial. Queda demostrado que la aplicación de algoritmos de IA es empleada con éxito para llegar a una resolución más rápida y eficiente del mencionado rompecabezas, y que la enseñanza de su resolución colabora al desarrollo de habilidades cognitivas y de pensamiento lógico en los estudiantes. Se espera que este aporte a la sociedad académica-científica genere una nueva línea de investigación en el desarrollo de habilidades cognitivas y de pensamiento lógico con el manejo de IA para resolución de diversos problemas en cualquier área.

Artificial intelligence, Algorithms, Logical thinking

Inteligencia artificial, Algoritmos, Pensamiento lógico

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Introduction

Artificial Intelligence is defined as a constellation of processes and technologies that enable computers to supplement or replace specific tasks that would otherwise be executed by humans, such as making decisions and solving problems.

Artificial Intelligence algorithms are sets of logical instructions that allow computers to learn and make autonomous decisions. These algorithms utilize techniques from machine learning, natural language processing, neural networks, genetic algorithms, and other AI methods to analyze vast amounts of data and identify patterns, enabling them to make decisions based on those patterns.

Artificial Intelligence is more than present in the reality we currently live in, as the developed algorithms are used in a wide range of applications, from weather prediction to autonomous driving. Therefore, it is of great importance to recognize their capabilities, which can be achieved through the analysis of various cases, such as the Rubik's Cube.

Understanding these Artificial Intelligence algorithms is crucial as they have a significant impact on society by enabling the development of new solutions. This impact will be explored by analyzing the specific case of solving the Rubik's Cube using these algorithms. However, the systematic study of scientific sources on the subject provides a clear understanding of them.

The development of the proposed research is divided into three main sections:

- Methodology to be developed, in which the steps followed to conduct the research are presented.
- Study Development, which includes the detailed description of the steps along with the activities carried out for each of them.
- Results, where the information obtained from the research is summarized and specified.

Metodology

It is evident that, as mentioned by Soto and Escriban (2019), the methodological procedure to be followed will always be governed, essentially, by the type of research being conducted and its objective, as well as by the typology of the case study being applied. Nevertheless, they outline certain steps that they consider fundamental in terms of the general methodological procedure of a case study, which are as follows:

1. Case study design.
2. Data collection.
3. Application of methods for obtaining relevant information, data, and evidence.
4. Analysis of the collected information.
5. Report writing.

In Figure 1, it's possible to see the mentioned methodological procedure and each of the steps it includes.

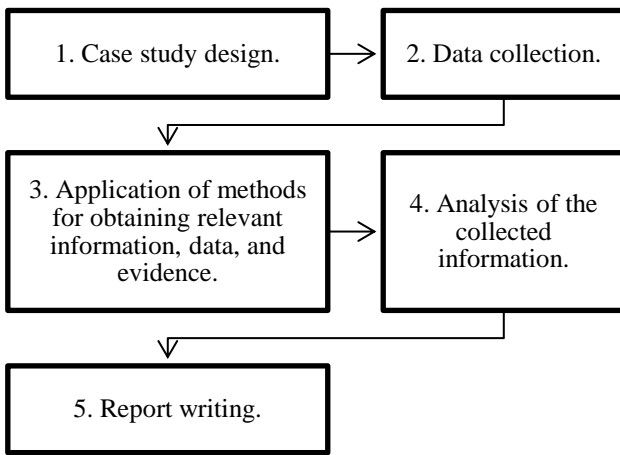


Figure 1 General methodological procedure of the case study
Source: self made

Next, the development of the study is described, in which the steps mentioned will be carried out as part of the methodological procedure.

Development of the study

The general methodological procedure of the case study is implemented to conduct the search for scientific information on the topics that concern us.

STEP 1: Case study design

Soto and Escriban (2019) mention that it is necessary to establish the following elements:

- Determination of background information on the topic.
- Formulation of the problem, scientific research questions, and their argumentation.
- Also, considering their relevance, timeliness, and significance for science and practical life.
- Determination of the final purpose or desired outcome.
- Selection of the research methods to be employed.

Currently, Artificial Intelligence algorithms, to some extent, function as solutions for cognitive and logical thinking problems. However, there is still a need for their implementation in the educational field with greater determination, as the contribution of this technology would have a significant impact in that domain.

Based on the aforementioned, we can formulate the problem at hand, which is the need to conduct an analysis of the impact of Artificial Intelligence algorithms that can be used in problem-solving. For this purpose, we propose to study the case of the Rubik's Cube. From the above, the following research question is delimited:

- *How do Artificial Intelligence algorithms impact education and the development of cognitive and logical thinking skills in students, including the relationship between teaching Rubik's Cube solving and the integration of artificial intelligence principles in it?*

The importance of the research question lies in its wide and continuous use in life and education. It's essential to understand how Artificial Intelligence algorithms can influence students' cognitive development and how teaching logical and cognitive skills, like solving the Rubik's Cube, can benefit from the integration of AI principles in its instruction.

Its relevance is rooted in the fact that the question allows for a deeper understanding of the impact of AI on education and students' cognitive development, providing a specific and concrete focus to analyze how integrating AI principles can enhance the teaching of logical and cognitive skills using the Rubik's Cube case. The impact of AI on education is a current and controversial topic, with widely diverse opinions. Some advocate that AI can enhance learning and help students develop skills that might be challenging to acquire otherwise, while others fear it could limit critical thinking and creativity.

Therefore, the proposed research question aims to address these issues by exploring how AI might affect students' cognitive development. Moreover, the choice of the Rubik's Cube as a case study allows for specific research on how integrating AI principles can enhance the teaching of logical and cognitive skills.

From a scientific standpoint, the question is relevant as it allows investigation into how AI can be effectively used in education to enhance the mentioned skills. It's also important because exploring the relationship between teaching Rubik's Cube solving and integrating AI principles can help develop new pedagogical methodologies and teaching strategies that promote meaningful learning and the development of essential 21st-century skills.

In practical terms, the question is important because the integration of AI in education can significantly impact students' training and their preparation to face current and future workforce challenges. Similarly, because solving the Rubik's Cube has been used in education to develop cognitive and logical thinking skills, its combination with AI can further enhance its effectiveness.

The research's purpose is to establish how AI algorithms can greatly contribute to the development of cognitive and logical thinking skills. Therefore, the expected outcome is a precise understanding of how these algorithms can assist us in problem-solving. It is then established that a documentary research approach will be employed as the research method. To achieve this, we need to identify the scientific sources for our search. Therefore, the following search tool is specified:

– *Reference or Bibliographic Management Tool: Mendeley.*

Mendeley is a reference manager, which is an academic program that assists in collecting, organizing, reading, annotating, and citing journal articles, book chapters, etc., used while writing research papers (ULPGC University Library, 2022).

It's worth mentioning that the search will encompass the years from 2020 to the current year, 2023.

STEP 2: Data collection.

In this step, clear and precise theoretical references are needed. Therefore, it's essential to establish the state of the art in the field and define the fundamental concepts upon which the research is based (Soto and Escriban, 2019). The search strings to be used in the search are defined based on the research question. These search strings are defined in Table 1, which is provided below.

Search strings
Inteligencia Artificial / Artificial Intelligence
Algoritmos / Algorithms
Habilidades Cognitivas/ Cognitive Skills
Pensamiento Lógico / Logical Thinking
Educación / Education
Cubo de Rubik / Rubik's Cube

Table 1 Search strings to be used to collect the information
Source: Self Made.

It's important to mention that the search for these strings will also be conducted in the English language. Figure 2 illustrates the search for the "Artificial Intelligence" string in the Mendeley tool used for this purpose.



Figure 2 Example of the results of the search string "Artificial Intelligence" in the Mendeley tool
Source: Self Made

STEP 3: Application of methods to obtain relevant information, data, and evidence

Soto and Escriban (2019) mention that every case study should be developed systematically, collecting detailed information related to the object of study. With the defined search strings in place, the search is then carried out. Table 2 displays the obtained results.

Search strings	Number of articles
Inteligencia Artificial / Artificial Intelligence	271,253
Algoritmos / Algorithms	3,671,387
Habilidades Cognitivas/ Cognitive Skills	126,682
Pensamiento Lógico / Logical Thinking	12,040
Educación / Education	3,627,900
Cubo de Rubik / Rubik's Cube	702
TOTAL	7,709,964

Table 2 Results for each search string in the Mendeley reference manager
Source: Self Made

Since the amount of information found is extensive, inclusion and exclusion criteria are defined in Table 3 to determine the references that will be used.

Inclusion criteria	Exclusion criteria
Scientific articles published in quality journals.	References that do not include any of the established search strings.
Scientific articles with a publication date between 2019 and 2023.	Duplicate scientific articles.
Scientific articles in Spanish and English.	Scientific articles that were not published in recent years.
Scientific articles that include at least one of the established search strings.	References that cannot be related to our objective.

Table 3. Inclusion and exclusion criteria to define the articles to be used in establishing the state of the art and the basic concepts to establish
Source: Self Made

By applying the inclusion and exclusion criteria, a filtering process was carried out, refining the conducted search and retaining the most relevant sources for the study. This refinement is illustrated in Table 4.

Search strings	Number of items
Artificial intelligence	5
Algorithms	5
Cognitive habilyties	5
Logical thinking	6
Education	4
Rubik's Cube	5
TOTAL	30

Table 4 Number of results after applying the criteria
Source: Self Made

It's evident that the research-specific information and the selected articles now meet all the established criteria.

STEP 4: Analysis of the collected information

It's clear that the processing and analysis of the obtained information should be handled rigorously (Soto and Escriban, 2019).

Using the articles that were determined to meet the established criteria, findings related to the study are identified. Table 5 displays the subset of articles relevant to the research question. Subsequently, the analysis of the information is presented in order to find answers to the research question.

#	Article title
1	Artificial Intelligence in Education: A Review
2	Artificial intelligence
3	Artificial intelligence in everything and for everyone
4	Artificial intelligence and its implications in higher education
5	A review on artificial intelligence in education
6	Design of algorithms in technology with Scratch for the development of Computational Thinking
7	Application of artificial intelligence algorithm in mathematical modelling and solving
8	Diagnostic performance of artificial intelligence algorithms for detection of lung involvement by COVID-19 based on portable radiography
9	Hybrid conflicts and the power of algorithms
10	Review of algorithms for artificial intelligence on low memory devices
11	Playful environmental education to strengthen cognitive abilities in school children
12	Mathematical skills for the development of cognitive skills in university students
13	Enrichment of cognitive abilities of children with outstanding aptitude
14	Cooperative learning and the development of cognitive skills
15	Cognitive and social skills in solving mathematical problems collaboratively
16	The game in the development of logical thinking
17	Sudoku game and development of mathematical logical thinking

18	Development of logical thinking in basic education
19	Didactic strategies for the development of mathematical logical thinking in children of initial education
20	Resolution of mathematical problems in the course of Mathematical Logical Thinking I
21	The relation between computational thinking and logical thinking in the context of robotics education
22	Challenges of education and learning in the Metaverse
23	Information technology in modern education
24	Strengthening critical thinking in higher education
25	Artificial intelligence in education: The three paradigms
26	Rubik’s Cube Solver
27	Application of a two-armed collaborative robot to solve the Rubik's Cube
28	Overview of Rubik’s cube and reflections on its application in mechanism
29	Designing Children's New Learning Partner: Collaborative Artificial Intelligence for Learning to Solve the Rubik's Cube
30	Rubik's cube as a tool for the development of spatial sense

Table 5. Most relevant articles regarding the research questions
Source: self made.

Specifically, a synthesis of the findings is presented to establish a clear understanding of the topic that allows for answering the research question.

Artificial Intelligence is a field of study that refers to innovations and developments resulting in computers, machines, and other artifacts with human-like intelligence characterized by cognitive abilities, learning, adaptability, and decision-making capabilities (Chen *et al.*, 2020).

According to Lope Salvador *et al.* (2020), the development of the internet and the Web, along with digitization and open access, are generating a vast amount of data. The treatment and analysis of this data using artificial intelligence techniques provide better insights into the impact of scientific publications and generate new knowledge.

On the other hand, Niebles (2020) specifies that everyone should know about AI, given that its impact will be so significant that it's necessary to represent everyone's viewpoint. Additionally, he mentions that AI can be very useful for training purposes, for instance, in learning how to assemble a device.

AI-based educational formats promise a substantial improvement in education across various levels. This improvement brings unprecedented qualitative enhancements by providing students with precise personalization of their learning tailored to their requirements. This approach integrates various forms of human interaction as well as information and communication technologies (Ocaña-Fernández *et al.*, 2019).

Indeed, as mentioned by Huang *et al.* (2021), one of the importance of AI in education is its role in promoting personalized teaching and learning. AI has changed the way teachers teach and students learn.

Hernández *et al.* (2022) discuss how various studies provide insights into the design of algorithms in technology within the school environment and their impact on mental development. Algorithm design involves determining the appropriate steps and organizing them into a series of instructions to solve a problem or complete a task correctly.

In recent years, with the rapid development of computer technology and artificial intelligence, the computing approach has been widely used in aspects like mathematical modeling. There are numerous intelligent algorithms for this purpose, such as artificial neural network methods, simulated annealing algorithms, genetic algorithms, and gray systems. These algorithms are characterized by machine learning, self-organization, adaptability, simplicity, universality, robustness, and adaptation to parallel processing (Yao, 2022).

The study presented by Cobeñas *et al.* (2022) concluded that AI algorithms based on portable X-rays allowed diagnostic accuracy comparable to human evaluation for detecting SARS-CoV-2 pneumonia. These findings are particularly relevant in contexts with significant human resource limitations, especially in emerging economies.

Algorithms, according to Cano (2021), and their specialized analytical capabilities are the new tools of 21st-century warfare, becoming strategic and invisible operational weapons capable of accelerating the transformation processes of people's trends and behaviors to change the reality of communities and nations.

According to Radanliev and Roure (2021), conceptual design involves individuals from different disciplines, utilizing a real synthesis of algorithmic, mathematical, computational, and engineering approaches. They mention that in the field of engineering, the evolution from dense multidimensional metrics to sparse, compact, and efficient AI algorithms could produce advancements in numerous practical applications.

Regarding cognitive skills, as referenced by Acuña *et al.* (2020), they are the various intellectual capacities individuals demonstrate when performing tasks. These qualities or traits are present when undertaking mental tasks and correspond to the development of an individual's potential capacities, whether through training or practice.

Jiménez Beleño (2022) notes that basic mathematical competencies enable students to acquire the skills and knowledge necessary for symbolic operations, using appropriate numerical language. It also involves decoding and interpreting formal and symbolic language to understand its relationship with everyday language. It develops logical thinking, abstraction, synthesis, concentration, analytical capacity, and other cognitive contributions.

Acquiring and consolidating a set of skills, as mentioned by González and Chávez (2021), allows mastery of different academic areas, promoting learning, which, in turn, influences people's life cycle.

Zurita Aguilera (2020) states that interaction in cooperative teams contributes to developing cognitive skills. As students socialize, they acquire, elaborate, and transfer knowledge and learning.

Related to this, Chandia *et al.* (2022) comment that systematic and uncontrolled collaborative problem-solving work promotes and modifies social and cognitive skills, such as interaction, understanding, planning, execution, monitoring of a plan, and evaluation of a strategy or solution.

Logical thinking aims to explain everyday life phenomena, as logically thinking helps humans understand how everything around them functions. It's important as it enables people to order their thoughts, express them clearly, and make correct interpretations or deductions, establishing the basis for rational operation and conducting a coherent, consistent, and systematic research process (Mazenett *et al.*, 2019).

Arias Hidalgo (2019) notes that mathematical logical thinking doesn't exist on its own in reality; rather, the root of this logical-mathematical reasoning lies within the individual. Each person constructs it through reflective abstraction born from coordinating actions with objects.

The development of logical thinking involves acquiring new codes, enabling communication with the environment. Logical-mathematical relationships constitute an essential foundation for acquiring knowledge in all academic areas relevant to future professions (Ciguencia Viteri *et al.*, 2019).

Celi Rojas *et al.* (2021) mention that socio-affective factors and teaching strategies delivered by educators are effective means for mastering logical-mathematical domains. It's essential for educators to use innovative strategies appropriate for the age of students, encouraging meaningful learning and the development of logical-mathematical thinking.

Likewise, Zenteno *et al.* (2019) conclude that teaching skills and strategies such as autonomy, self-direction, and self-regulation contribute to solving mathematical problems.

Chen *et al.* (2020) comment that AI systems, leveraging machine learning and adaptability, have personalized the educational curriculum and content in line with student needs. This has promoted adoption and retention, improving both student experience and overall quality of learning.

The Rubik's cube is considered the most interesting and challenging problem in the world, defined as a 3D combination puzzle originally called the magic cube, which has only one correct solution out of 43 quintillion possibilities (Srivastava, 2021).

The Rubik's cube is an axis mechanism that allows each of its faces to rotate independently, causing the colors to mix. To solve the puzzle, each of its faces must consist of a single color, requiring a set of skills such as concentration, memory, hand-eye coordination, mathematics, and mental agility, among others (Fernández *et al.*, 2021).

Studying the mechanism of the cube and promoting the development of its structure, as mentioned by Zeng *et al.* (2019), is of great importance. It is believed that the Rubik's Cube will have broad application prospects in the machinery industry based on its research status and will have a spillover effect on various scientific investigations, including mathematics, physics, computer science, and biology.

Agostinelli *et al.* (2021) note that since artificial intelligence has been used to solve problems in a wide range of domains, it offers unique opportunities to develop problem-solving skills using a multitude of tasks that spark curiosity.

Porras *et al.* (2019) states that using the Rubik's cube as a resource to incentivize and develop a sense of spatial and planar geometry will encourage the exploration of other types of activities that stimulate mathematical learning using the Rubik's cube and its different versions. This aims to propose new activities to address the teaching and learning of two-dimensional and three-dimensional geometry.

STEP 5: Report Writing

It is important, as highlighted by Soto and Escriban (2019), to provide necessary information about the causes and potential consequences of the investigated issue. Therefore, a clear understanding of the researched subject, proper utilization of research methods, procedures, and techniques, accurate interpretation of obtained information, and the proposal and argumentation of scientific solutions to the problem must be demonstrated (Soto and Escriban, 2019).

Given the above, in the following section, in the form of a report, a summary of the obtained information will be presented, while simultaneously addressing the research question posed.

Results

Significant information was obtained regarding the topics under consideration. It is noted that AI refers to innovations and developments that have resulted in computers, machines, and other artifacts with human-like intelligence. Furthermore, the processing and analysis of large amounts of data using AI techniques can provide better insights into the impact of scientific publications and generate new knowledge.

Concerning AI algorithms, it is stated that their design involves determining appropriate steps to solve a problem or task, and several intelligent algorithms used in mathematical modeling are mentioned, such as artificial neural networks, simulated annealing, genetic algorithms, and grey systems.

In the educational context, it is emphasized that AI-based instructional formats can personalize student learning and enhance human interaction and information and communication technology. Additionally, it is highlighted that AI has transformed how teachers teach and students learn.

Similarly, AI algorithms are positioned as strategic tools capable of accelerating the transformation of trends and behaviors of individuals and altering the reality of communities and nations. The significance of cognitive skills and basic mathematical competencies as key elements in education and the development of intellectual capacities is also discussed.

Regarding the Rubik's Cube, it is defined as a challenging puzzle requiring skills such as concentration, memory, hand-eye coordination, mathematics, and mental agility to solve. Its axis mechanism allows each face to rotate independently, making it an interesting subject for industry and scientific research.

Furthermore, the Rubik's Cube has been used as a resource to encourage and develop spatial and planar geometry awareness, opening new opportunities for teaching and learning mathematics. AI has also been employed to solve the Rubik's Cube, providing a unique opportunity to develop problem-solving skills across a wide range of domains.

Proceeding to answer the research question:

- *How do Artificial Intelligence algorithms impact education and the development of cognitive and logical thinking skills in students, including the relationship between teaching Rubik's Cube solving and the integration of artificial intelligence principles in it?*

Artificial intelligence is having a significant impact on education and the development of cognitive and logical thinking skills in students. Thanks to AI algorithms, learning can be personalized, transforming the way teachers teach and students learn.

Similarly, AI is used in mathematical modeling and the design of algorithms to solve complex problems and tasks, as in many other fields. The development of cognitive skills such as problem-solving and logical thinking is crucial for students' growth. AI algorithms can greatly enhance these skills due to their adaptability, simplicity, and parallel information processing capabilities.

At times, the direct connection between teaching Rubik's Cube solving and integrating artificial intelligence principles might not be apparent. However, both are related to cognitive skill development and machine learning.

Teaching Rubik's Cube solving is an activity that fosters the development of cognitive skills, such as visual perception and problem-solving. Additionally, as mentioned, integrating artificial intelligence principles can enable personalized learning tailored to students' needs and bring qualitative improvements to education.

It is evident that artificial intelligence is also highly useful in solving complex mathematical problems, which is highly relevant in the context of Rubik's Cube solving.

Conclusions

Artificial intelligence is reshaping education and the development of cognitive and logical thinking skills in students. Artificial intelligence algorithms have the capability to personalize learning and enhance human interaction and information communication technology.

Additionally, artificial intelligence is also used in mathematical modeling and designing algorithms to solve complex problems and tasks.

Consequently, teaching Rubik's Cube solving is an activity that nurtures cognitive and problem-solving skills, which is of significant importance for mathematics learning and the application of artificial intelligence. Thus, it is evident that artificial intelligence algorithms hold substantial potential to revolutionize education and the development of cognitive and logical thinking skills in students, which will undoubtedly have a positive impact on their future and society's overall progress.

References

- Acuña Agudelo, M. P., & Quiñones Tello, Y. del C. (2020). Educación ambiental lúdica para fortalecer habilidades cognitivas en niños escolarizados. *Educación y Educadores*, 23(3), 444–468.
<https://doi.org/10.5294/edu.2020.23.3.5>
<https://educacionyeducadores.unisabana.edu.co/index.php/eye/article/view/11379/6071>
- Agostinelli, F., Mavalankar, M., Khandelwal, V., Tang, H., Wu, D., Berry, B., ... Irvin, M. (2021). Designing Children's New Learning Partner: Collaborative Artificial Intelligence for Learning to Solve the Rubik's Cube. In *Proceedings of Interaction Design and Children, IDC 2021* (pp. 610–614). Association for Computing Machinery, Inc.
<https://doi.org/10.1145/3459990.3465175>
- Arias Hidalgo, E. N. (2019). Juego Sudoku y desarrollo del pensamiento lógico matemático. *REVISTA DESAFÍOS*, 1(2), 152–157.
<https://doi.org/10.37711/desafios.2019.1.2.75>
<http://revistas.udh.edu.pe/index.php/udh/article/view/75e/135>
- Bakytgul Abykanova, Shynar Yelezhanova, Aiman Mailybayeva, Dinara Sadirbekova, Gulnur Turmukhanova, & Kydyr Kabiden. . (2019). La tecnología de la información en la educación moderna. *Dilemas Contemporáneos: Educación, Política y Valores*.
<https://doi.org/10.46377/dilemas.v27i1.1576>
<https://dilemascontemporaneoseducacionpoliticayvalores.com/index.php/dilemas/article/view/1576/1568>
- Cano M., J. J. (2021). Los conflictos híbridos y el poder de los algoritmos. *Revista SISTEMAS*, (161), 62–72.
<https://doi.org/10.29236/sistemas.n161a6>
<https://sistemas.acis.org.co/index.php/sistemas/article/view/168/132>
- Celi Rojas, S. Z., Catherine Sánchez, V., Quilca Terán, M. S., & Paladines Benítez, M. del C. (2021). Estrategias didácticas para el desarrollo del pensamiento lógico matemático en niños de educación inicial. *Horizontes. Revista de Investigación En Ciencias de La Educación*, 5(19), 826–842.
<https://doi.org/10.33996/revistahorizontes.v5i1.9.240>
<https://revistahorizontes.org/index.php/revistahorizontes/article/view/261>
- Chandia, E., Huencho, A., Pérez, C., Ortiz, A., & Cerda, G. (2022). Habilidades cognitivas y sociales en la resolución de problemas matemáticos de forma colaborativa. *Uniciencia*, 36(1), 1–26. <https://doi.org/10.15359/ru.36-1.50>
<https://www.revistas.una.ac.cr/index.php/uniciencia/article/view/16358/26429>
- Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. *IEEE Access*, 8, 75264–75278.
<https://doi.org/10.1109/ACCESS.2020.2988510>
<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9069875>
- Ciguencia Viteri, B. I., Zambrano García, J. F., & Alvarado Herrera, D. M. (2019). Desarrollo del pensamiento lógico en la educación básica. *Revista Tecnológica Ciencia Y Educación Edwards Deming*, 2(2), 30–47.
<https://doi.org/10.37957/ed.v2i2.13>
<https://revista-edwardsdeming.com/index.php/es/article/view/13/26>
- Cobeñas, R. L., de Vedia, M., Florez, J., Jaramillo, D., Ferrari, L., & Re, R. (2023). Rendimiento diagnóstico de algoritmos de inteligencia artificial para detección de compromiso pulmonar por COVID-19 basados en radiografía portátil. *Medicina Clínica*, 160(2), 78–81.
<https://doi.org/10.1016/j.medcli.2022.04.016>
<https://www.sciencedirect.com/science/article/pii/S002577532200313X?pes=vor>

Fernández, G., Herrán, A., Mancisidor, A., Pérez, C., Cabanes, I. Aplicación de un robot colaborativo de dos brazos para resolver el cubo de Rubik. En XLII Jornadas de Automática: libro de actas. Castelló, 1-3 de septiembre de 2021 (pp.611-616). DOI capítulo: <https://doi.org/10.17979/spudc.9788497498043.611> DOI libro: <https://doi.org/10.17979/spudc.9788497498043> https://ruc.udc.es/dspace/bitstream/handle/2183/28344/2021_Garazi_Fernandez_Asier_Herran_Aplicacion_de_un_robot_colaborativo_de_dos_brazos_para_resolver_el_cubo_de_Rubik.pdf;jsessionid=D0C3611F995311490AEA27A102B6609F?sequence=6

González Arreola, M. R., & Chávez Soto, B. I. (2021). Enriquecimiento de las habilidades cognitivas de niños con aptitud sobresaliente. *Revista Virtual Universidad Católica Del Norte*, (64), 65–91. <https://doi.org/10.35575/rvucn.n64a4> <https://revistavirtual.ucn.edu.co/index.php/RevistaUCN/article/view/1275/1649>

Hernández Suárez, C. A., Gamboa Suárez, A. A., & Avendaño Castro, W. R. (2022). Diseño de algoritmos en tecnología con Scratch para el desarrollo del Pensamiento Computacional. *Revista Boletín Redipe*, 11(2), 461–476. <https://doi.org/10.36260/rbr.v11i2.1696> <https://revista.redipe.org/index.php/1/article/view/1696/1608>

Huang, J. ., Saleh, S. ., & Liu, Y. . (2021). A Review on Artificial Intelligence in Education. *Academic Journal of Interdisciplinary Studies*, 10(3), 206. <https://doi.org/10.36941/ajis-2021-0077> <https://www.richtmann.org/journal/index.php/ajis/article/view/12463/12063>

Jiménez Beleño, A. (2022). Competencias matemáticas para el desarrollo de habilidades cognitivas en estudiantes universitarios. *Revista Latinoamericana de Difusión Científica*, 4(7), 141–167. <https://doi.org/10.38186/difcie.47.10> <https://difusioncientifica.info/index.php/difusioncientifica/article/view/70/133>

Lope Salvador, V., Mamaqi, X., & Vidal Bordes, J. (2020). La inteligencia artificial. *Revista ICONO14 Revista Científica de Comunicación y Tecnologías Emergentes*, 18(1), 58–88. DOI: <https://doi.org/10.7195/ri14.v18i1.1434> <https://icono14.net/ojs/index.php/icono14/article/view/1434/1603>

Mazenett, J., Trujillo, N., Rodríguez, M., & Bocanegra, C. (2019). El juego en el desarrollo del pensamiento lógico. II Congreso Latinoamericano de Ingeniería, 9. Retrieved from <https://acofipapers.org/index.php/eiei/article/view/57/52>

Meyzan Briceño, M. A. (2022). Desafíos de la educación y el aprendizaje en el Metaverso. *Desafios*, 13(1), e368. <https://doi.org/10.37711/desafios.2022.13.1.368> <http://revistas.udh.edu.pe/index.php/udh/article/view/368e/276>

Niebles, Juan Carlos (2020). Inteligencia artificial en todo y para todos. *Revista Digital Universitaria (RDU)*. Vol. 21, núm. 1 enero-febrero. DOI: <http://doi.org/10.22201/codeic.16076079e.2020.v21n1.a5> https://www.revista.unam.mx/wp-content/uploads/v21_n1_a5.pdf

Ocaña-Fernandez, Y., Valenzuela-Fernandez, L., & Garro-Aburto, L. (2019). Inteligencia artificial y sus implicaciones en la educación superior. *Propósitos y Representaciones*, 7(2), 536-568. DOI: <http://dx.doi.org/10.20511/pyr2019.v7n2.274> <https://revistas.usil.edu.pe/index.php/pyr/article/view/274/552>

Ouyang, F., & Jiao, P. (2021). Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence*, 2. <https://doi.org/10.1016/j.caeai.2021.100020> <https://reader.elsevier.com/reader/sd/pii/S2666920X2100014X?token=8D40EB1BB3F52594ECA8A4232F9606367156866C4F8AF025DE2FBE5E418B57DEDC1E755C659ACF95EA13DBB557DF3121&originRegion=us-east-1&originCreation=20230515171328>

Porras, K., Ramírez, J., & Céspedes, M. (2019). Cubo de Rubik como herramienta para el desarrollo del sentido espacial. In Y. Morales & M. Picado (Eds.), *Memorias del VII Encuentro Provincial de Educación Matemática* (pp. 1–3). Universidad Nacional. Retrieved from <http://www.mep.go.cr/sites/default/files/programeestudio/programas/matematica.ppt>
<http://funes.uniandes.edu.co/20013/1/Porras2019Cubo.pdf>

Radanliev, P., & Roure, D. D. E. (2021). Review of algorithms for artificial intelligence on low memory devices. *IEEE Access*. Institute of Electrical and Electronics Engineers Inc. <https://doi.org/10.1109/ACCESS.2021.3101579>
<https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9502714>

Rivadeneira Barreiro, M. P., Hernández Velásquez, B. I., Llor Lara, D. L., & Palma Villavicencio, M. M. (2019). El fortalecimiento del pensamiento crítico en la educación superior. *Revista Boletín Redipe*, 8(11), 44–49. <https://doi.org/10.36260/rbr.v8i11.845>
<https://revista.redipe.org/index.php/1/article/view/845/772>

Soto Ramírez, E. R. & Escribano Hervis, E. (2019). [El método estudio de caso y su significado en la investigación educativa]. *Procesos formativos en la investigación educativa: Diálogos, reflexiones, convergencias y divergencias* (pp. 203-222). México: Editorial. ISBN: 978-607-98139-1-8.

Srivastava, S. (2021). Rubik's Cube Solver. *International Journal for Research in Applied Science and Engineering Technology*, 9(VII), 3223–3227. <https://doi.org/10.22214/ijraset.2021.37032>

ULPGC Biblioteca Universitaria. (2022, Mayo 2). ULPGC Biblioteca Universitaria. Retrieved from <https://biblioguias.ulpgc.es/mendeley>

Veenman, K., Tolboom, J. L. J., & van Beekum, O. (2022). The relation between computational thinking and logical thinking in the context of robotics education. *Frontiers in Education*, 7. <https://doi.org/10.3389/feduc.2022.956901>

Yao, H. (2022). Application of artificial intelligence algorithm in mathematical modelling and solving. *Applied Mathematics and Nonlinear Sciences*, 7(1), 449–456. <https://doi.org/10.2478/amns.2021.2.00081>
<https://sciendo.com/article/10.2478/amns.2021.2.00081>

Zeng, D. X., Li, M., Wang, J. J., Hou, Y. L., Lu, W. J., & Huang, Z. (2018, August 1). Overview of Rubik's cube and reflections on its application in mechanism. *Chinese Journal of Mechanical Engineering (English Edition)*. Chinese Mechanical Engineering Society. <https://doi.org/10.1186/s10033-018-0269-7>

Zenteno Ruiz, F. A., Carhuachin Marcelo, A. I., & Rivera Espinoza, T. A. (2018). Resolución de problemas matemáticos en el curso de Pensamiento Lógico Matemático I. *Horizonte de La Ciencia*, 8(15), 149. <https://doi.org/10.26490/uncp.horizonteciencia.2018.15.460>
<https://www.redalyc.org/journal/5709/570960688012/570960688012.pdf>

Zurita Aguilera, M. S. (2020). El aprendizaje cooperativo y el desarrollo de las habilidades cognitivas. *Revista EDUCARE - UPEL-IPB - Segunda Nueva Etapa 2.0*, 24(1), 51–74. <https://doi.org/10.46498/reduipb.v24i1.1226>

Bibliometric Analysis of Smart Parking

Análisis bibliométrico del aparcamiento inteligente

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Abstract

For more than a decade, technological advances have been generated to manage the available spaces in a public parking lot to improve the use of the available infrastructure. In this paper, we identify the most relevant contributions to the field of Smart Parking, using Bibliometric analysis techniques, highlighting the technological assistance, the principal authors, publishing houses, countries with greater participation, and the trend of publications from January 1, 2012, to December 31, 2022. The Web of Science identified 1643 publications related to intelligent parking. These involve 5,855 authors and co-authors, with the participation of 154 publishers and 2.178 institutions in 103 countries or territories. Besides, it was considered a sample of the first four months of 2023, reflecting a result of 73 publications, showing fewer publications than previous years. This analysis allows identifying the existence of a large amount of collaborative research on the implementation of technologies to achieve an efficient distribution and management of vehicular spaces, showing a trend in the development area in this field.

Bibliometric analysis, Smart parking, Web of Science

Resumen

Desde hace más de una década se vienen generando avances tecnológicos para gestionar las plazas disponibles en un aparcamiento público con el fin de mejorar el uso de la infraestructura disponible. En este trabajo se identifican las contribuciones más relevantes en el campo del aparcamiento inteligente, utilizando técnicas de análisis bibliométrico, destacando la asistencia tecnológica, los autores principales, las editoriales, los países con mayor participación y la tendencia de las publicaciones desde el 1 de enero de 2012 hasta el 31 de diciembre de 2022. La Web of Science identificó 1643 publicaciones relacionadas con el aparcamiento inteligente. En ellas participan 5.855 autores y coautores, con la participación de 154 editoriales y 2.178 instituciones de 103 países o territorios. Además, se consideró una muestra del primer cuatrimestre de 2023, reflejando un resultado de 73 publicaciones, mostrando menos publicaciones que años anteriores. Este análisis permite identificar la existencia de una gran cantidad de investigaciones colaborativas sobre la implementación de tecnologías para lograr una eficiente distribución y gestión de espacios vehiculares, mostrando una tendencia en el área de desarrollo en este campo.

Análisis bibliométrico, Smart parking, Web of Science

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I. Introduction

The vast number of scientific articles available creates difficulties for researchers to grasp the developing trends adequately, hindering the understanding of the existing relationship between various advancements (Rodrigues, Van Eck, Waltman, & Jansen, 2014). Bibliometric analysis is a tool used to establish a knowledge base and practices to manage the systematic literature review process in the face of significant academic publications. The association of data offers a tool to analyze records and extract information about research outcomes based on variables like time and distance (Espinosa, 2020).

When embarking on developing a technological project that offers solutions to diverse identified problems, researchers and developers face the challenge of reviewing and studying hundreds, and at times thousands, of contributions developed worldwide. The bibliographic analysis proposes identifying the most relevant publications that provide deeper specialization on the topic.

This descriptive article aims to provide a macroscopic view of the main trends in publications related to Smart Parking through bibliometric analysis. The information presented in this document offers an overview of the research progress achieved in the domain of technology applied to intelligent parking to aid researchers and professionals in identifying the fundamental influences of authors, journals, countries, institutions, references, and research topics.

Bibliometric analysis techniques are the most reliable and accurate for mapping bibliographic studies, as they enable the classification and visualization of a network of research contributions and related collaborators (Pranckutė, 2021).

II. Data and Methods

The goal of a bibliometric article is to identify existing innovations as well as publication characteristics. The data for this study were obtained from the Web of Science (WoS), using a sample spanning the last decade from January 1, 2012, to December 31, 2022.

This search engine was selected because it is a primary and most comprehensive metadata source related to publications and impact indicators (Van Eck, 2013). The terms "Smart" and "Parking" were used for the developed search. It was identified that they yield relevant results compared to words like "smart parking" or "vehicle intelligent parking."

Web of Science displays 1,643 publications; the database includes an "analyze results" section that allows visualizing information through tree maps, tables, and bar graphs. Based on the obtained results, the decision was made only to consider the following variables: types of published documents (1), publication production and growth trends (2), authors and their cooperation (3), journals publishing about Smart Parking (4) and geographical and institutional distribution and collaboration (5).

We used the free VOSviewer software to analyze, visualize, and complement the data. VOSviewer provides techniques for assessing the interdisciplinarity of organizations or document sets through correlation diagrams (Leydesdorff, 2012).

Web of Science has limitations when graphically representing relationships between authors, countries, and organizations. VOSviewer, in addition to providing these correlations, also displays co-authorships, citations, academic institutions, and keywords with either full or fractional counting methods (Boyack, 2010).

Web of Science

Web of Science enables the export of search data across various subsets. Downloads of records are constrained to processing in increments of 500 results. Downloading in formats such as EndNote Online and EndNote Desktop is a choice. Additionally, an option exists to add to a search profile. The first set of record downloads covers entries from 01 to 500, the second from 501 to 1000, and so forth. These subsets allow the retrieval of records in increments of 1000, presented in formats including plain text, RefWorks, RIS File, BibTeX File, Excel, Tab Delimited File, Printable HTML File, and Email Records, for limited record downloads of 500 or 1000.

Web Science offers the capability to select up to 29 parameters, catering to requirements for custom data visualization. Lastly, as the name suggests, the "Fast 5000" format enables the download of subsets containing up to 5000 results provided by Web of Science. This option restricts downloading parameters such as author names, publication titles, and sources. For this study, some tree maps and bar chart graphics were extracted from the Web of Science, summarizing the most prominent results of the previously considered variables.

III. Results

Published documents

The significance of the number of publications lies in its reflection of developmental trends within the area of interest, which pertains to parking facilities. Table 1 elucidates that 95.131% of the publications correspond to research articles, followed by review articles at 3.895%, book chapters at 3.287%, 2.009% for early access documents, and 1.217% for proceeding papers. Additionally, nine distinct document types exist, exclusive of those above. These encompass editorial materials at 0.426%, data papers at 0.304%, retracted publications at 0.183%, corrections at 0.122%, meeting abstracts at 0.122%, art exhibit reviews at 0.061%, book reviews at 0.061%, letters at 0.61%, news items at 0.61%, and retractions at 0.12%.

Document Types	Record Count	% of 1643
Article	1,563	95.131%
Review Article	64	3.895%
Book Chapters	54	3.287%
Early Access	33	2.009%
Proceeding Paper	20	1.217%
Editorial Material	7	0.426%
Data paper	5	0.304%
Retracted Publications	3	0.183%
Correction	2	0.122%
Meeting Abstract	2	0.122%
Art Exhibit Review	1	0.061%
Book Review	1	0.061%
Letter	1	0.061%
New Item	1	0.061%
Retraction	1	0.061%

Table 1 Types of published documents

It is noteworthy and warrants mention that the cumulative percentages provided by the Web of Science bibliographic reference database surpass 100%. In essence, the final figure of 1758 documents stands as opposed to the 1643 publications indicated by the sample. This phenomenon arises due to document duplication from various perspectives. For instance, certain documents are included as part of book articles and reviews.

With 1643 publications rooted in the domain of "Smart Parking", we can infer the contemporaneity and pronounced interest in this subject within the realm of research. This is heightened interest, primarily driven by the need for parking availability in densely urbanized areas characterized by a high concentration of vehicles in confined spaces, such as shopping centers, schools, recreational zones, and more.

Publications by Year

Figure 1 allows observing variations concerning the growth depicted in the table. While a decrease in publications from 2012 to 2013 was observed, the change in publications from 2013 to 2014 exhibited a 194% increase. Subsequent growth trends manifested as follows: a 2% increase from 2014 to 2015, a 32% increase from 2015 to 2016, a 52% increase from 2016 to 2017, a 61.26% increase from 2017 to 2018, a 17.31% increase from 2018 to 2019, a 12.85% increase from 2019 to 2020, and a 43.45% increase from 2020 to 2021. Variations in publication decline also occurred, with the first being a drop from 56 publications in 2014 to 55 publications in 2015, constituting a 2% decrease. The second variation occurred in 2022, with 310 publications compared to 340 in 2021, resulting in an 8.82% decrease. Despite these fluctuations, a discernible upward trend remains evident.

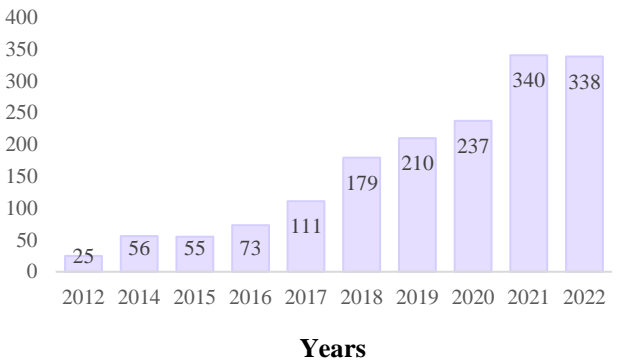


Figure 1 Number of publications per year from 2012 to 2022

Web of Science excludes 2013 when representing academic production in bar graphs. Publications for that year were obtained by adjusting the parameter for each year, revealing 19 publications, as depicted in Figure 2.

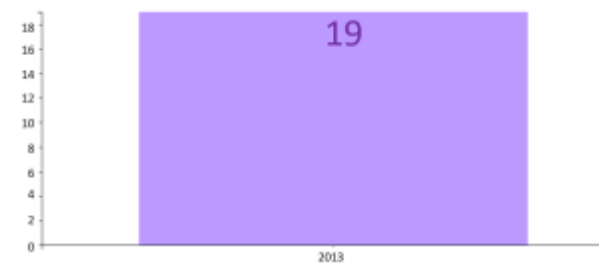


Figure 1 Publications from the Year 2019

In 2023, as depicted in Figure 3, Web of Science presents a lower number than in previous years, amounting to only 73 publications. For the sampled period spanning January 1, 2023, to April 30, 2023, this serves as a reference for the behavior that publications might exhibit this year. If the 73 exclusive publications from 2023, as indicated by Web of Science, are considered, and if publications maintain this pace, an estimated 291 publications will be expected throughout the year. This number needs to be revised in both 2021 and 2022.

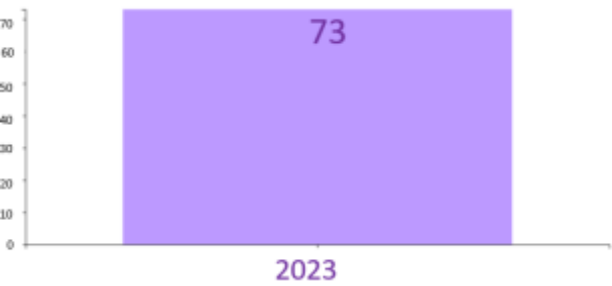


Figure 2 Publications from the Year 2023

Author	Docum ents	Citati ons	Total link strength
catalao, joao p.s.	13	697	30
misak, stanislav	7	16	30
prokop, lukas	7	16	30
blazek, vojtech	6	9	29
shafie-khah, miadreza	13	684	29
bajaj, mohit	5	7	28
dong, liang	8	440	28
ben-akiva, moshe	6	109	24
chen, bin	3	53	23
haidery, saqib ali	4	54	23
ullah, hidayat	4	54	23
wan, wanggen	4	54	23
mohammadi- ivatloo, behnam	8	121	22
moroni, davide	4	59	22
pieri, gabriele	4	59	22
ren, jingzheng	4	268	22
ancona, massimo	1	1	20
balbi, evandro	1	1	20
boccacci, patrizia	1	1	20
bracco, gianangelo	1	1	20

Table 2 VOSviewer shows reference.

An explanation for the decrease in publication numbers can be found in Price's Law, which assesses the overall growth of scientific publications in a specific research domain (Ardanuy, 2012). According to this law, the development of a research domain undergoes four stages: the first stage is that of pioneers, where a small body of scientists begins to publish in a new field, as reflected in the years 2012 and 2013.

The second stage is exponential growth, where an increasing number of scientists express interest in the various aspects of the topic that remain to be explored, aligned with emerging technologies and new implementations, as demonstrated in the graph from 2014 to 2021. The third stage involves the consolidation of the body of knowledge, noted from 2021 to 2022, and the fourth stage witnesses a decline in the number of publications, less pronounced during the years 2021 to 2022 and more pronounced in 2022, as evidenced by the behavior in 2023 (Price, 1963).

Publications by Authors, Coauthors, and Citations

The maximum number of articles published by an author related to Smart Parking is 13, with Catalao Joao P. S. and Shafie-khah Miadreza emerging as the principal contributors, as illustrated in Figure 4.

Table 2 showcases the accomplished documents, the count of citations generated by their works, and the total link strength. The full link strength signifies the number of publications in which two keywords appear together. The table elucidates the citation count and the associations with other authors that each author holds. The table shows the six authors wielding the highest citation counts, indicating their influence's magnitude. Foremost, Catalao Joao P. S. boasts 13 publications and has been cited 697 times. In the second position stands Shafie-khah Miadreza, with 13 publications and cited 684 times. Dong Liang occupies the third position with eight publications and 440 citations. Ren Jingzheng ranks fourth with four publications and 268 sources. Mohammadi-Ivantloo Behnam holds the fifth spot with eight publications and 121 citations. Ben-Akiva Moshe holds the sixth position with six publications and 109 citations.



Figure 4 Authors

This elevated citation index beckons researchers keen on contributing to technological advancement in enhancing parking efficiency or user experience to peruse the works of these authors.

The pattern of cooperation, signifying co-authorship, among authors delving into the realm of Smart Parking reveals that they have collectively published at least two articles on the subject. When graphing the results, among the 1,643 publications showcased by Web of Science, the presence of 1,419 co-authored works is evident.

The result of this authors' cooperation network is shown in Figure 5. The size of the circles represents the number of publications, and the thickness of the line between the two authors represents the strength of cooperation between them.

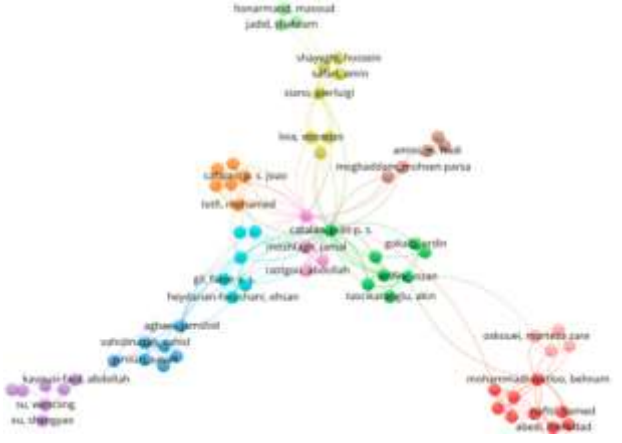


Figure 5 Cooperative Work Relationship Among Authors

The colors represent collaboration groups. In this cooperation network, three major author groups are distinguished. The primary researchers in the network are Catalao Joao P. S., Shafie-khah Miadreza, and Mohammadi-Ivantloo Behnam. There are other researchers linked to one of these primary researchers.

Publishers and Publication Journals

A total of 154 publishers published the reviewed documents. Figure 6 shows the top 10 publication journals or publishers, with four publishers standing out: Elsevier is the first with 419 publications, followed by IEEE with 280 publications. In third place is Mdpi with 264 publications, and fourth is Springer Nature with 139 publications. The results show that 14.93% (23 publishers) generate 88.06% of the total publications, leaving the rest with a combined output of 11.931%, publishing fewer than five articles per publisher.

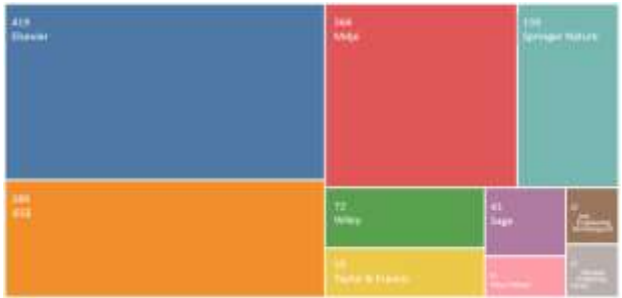


Figure 6 Main publishers identified

As Elsevier is a global company that provides researchers with information analysis for scientific progress, we infer that the obtained results are helpful to be utilized as a foundation for the execution of innovation projects for the benefit of humanity. In the case of interest, the use of free public parking in urban areas.

Additionally, the high number of identified publishers indicates a wide variety of research topics and the multidisciplinary nature of *Smart parking* culture research.

Geographical Distribution of Institutions and Cooperation

Each publication was assigned to a country or territory and an institution based on the authors' addresses as indicated in the Web of Science data. The total count of countries in the Web of Science database is 103. Figure 7 shows the number of articles and the geographical location where they were published. It observed a consistent trend in the Chinese Republic, with 380 publications, followed by the United States, with 283. The United States is the only country in the Americas in the top 20 places for article publication. Due to author collaboration, an author could be affiliated with more than one country or territory. Similarly, a publication could be written by several authors from different countries or regions.(Van Nunen, 2018).

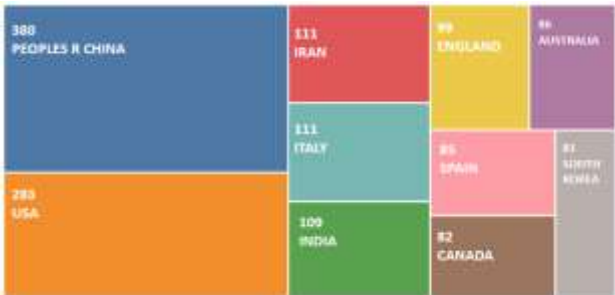


Figure 7 Main Countries and Territories of publication identified

As seen in other domains of scientific research, collaborating countries tend to be geographically correlated and centered around the most productive countries in terms of publication output (Zheng, 2016).

Figure 8 presents the result of the cooperation network among countries and territories. The size of the circles represents the number of publications, and the thickness of the links represents the strength of collaborations. The colors represent collaboration groups. Two main groups can be distinguished, one centered around China.

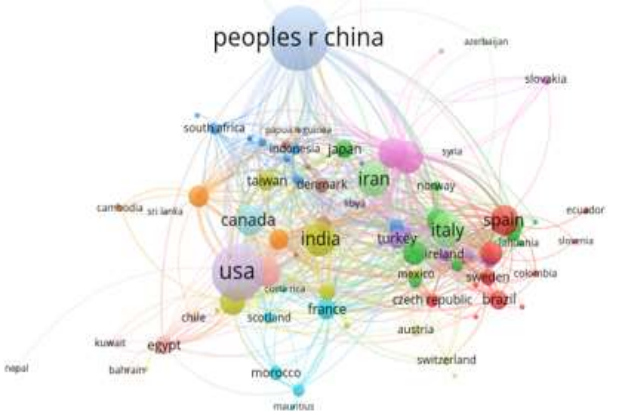


Figure 8. List of publications with country collaborations

IV. Funding

The author funded this work with the CONAHCYT scholarship [grant number 968871] and resources from co-authors who participated in the article.

V. Conclusions

This article presented a brief synthesis of a quantitative study on the literature review regarding Smart parking-related articles, applying bibliometric analysis using publications from the Web of Science database and the VOSviewer tool. A consistent increase with slight variations in publication reductions in some years among researchers in the last decade, from 2012 to 2022 and from January to April 2023, was demonstrated. Smart parking is defined as a current and innovative topic of interest.

The results of this analysis can serve as a reference for researchers, industry, and the government sector for the improvement and implementation of new technologies aimed at enhancing processes and the quality of life for individuals in developed or developing countries, specifically for the optimization of public parking in densely populated urban areas. During the creation of this bibliometric analysis, the data consulted in the most recent days of the Web of Science platform showed constant changes. The period of year change was more noticeable at the close of 2022 and the first months of 2023 due to records that we assume are still being processed for publication.

VI. References

Ardanuy, J. (2012). Breve introducción a la bibliometría. La base de datos scopus y otros e-recursos del CBUES como instrumento de gestión de la actividad investigadora; 1. <https://diposit.ub.edu/dspace/bitstream/2445/30962/1/breve%20introduccion%20bibliometria.pdf>

Boyack, K. W. (2010). Co-citation analysis, bibliographic coupling, and direct citation: Which citation approach represents the research front most accurately?. *Journal of the American Society for information Science and Technology*, 2389-2404. <https://onlinelibrary.wiley.com/doi/epdf/10.1002/asi.21419> <https://doi.org/10.1002/asi.21419>

Espinosa, M. A. (2020). DANDELION: Propuesta metodológica para recopilación y análisis de información de artículos científicos. Un enfoque desde la bibliometría y la revisión sistemática de la literatura. *Revista Ibérica de Sistemas e Tecnologías de Informação*, 110-122. <https://www.proquest.com/docview/2388305298/fulltextPDF/BB15A7D0A883426EPQ/1?accountid=28915>

Leydesdorff, L. &. (2012). Interactive overlays: A new method for generating global journal maps from Web-of-Science data. *Journal of Informetrics*, 318-332. <https://arxiv.org/ftp/arxiv/papers/1105/1105.2925.pdf> <https://doi.org/10.1016/j.joi.2011.11.003>

Pranckutė, R. (2021). Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world. *Publications*, 12. <https://www.mdpi.com/2304-6775/9/1/12> <https://doi.org/10.3390/publications9010012>

Price, D. J. (1963). Little science, big science. *Columbia University Press*. <https://www.degruyter.com/document/doi/10.7312/pric91844/pdf> <https://doi.org/10.7312/pric91844>

Rodrigues, S. P., Van Eck, N. J., Waltman, L., & Jansen, F. W. (2014). Mapping patient safety: a large-scale literature review using bibliometric visualisation techniques. *BMJ open*. <https://bmjopen.bmj.com/content/4/3/e004468> <http://dx.doi.org/10.1136/bmjopen-2013-004468>

Van Eck, N. J. (2013). VOSviewer manual. *Leiden: Univeriteit Leiden*, 1-53. https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.10.pdf

Van Nunen, K. L. (2018). Bibliometric analysis of safety culture research. *Safety science*, 248-258. https://repository.uantwerpen.be/docman/irua/69f95d/145112_2020_08_24.pdf <https://doi.org/10.1016/j.ssci.2017.08.011>

Zheng, T. W. (2016). A bibliometric analysis of micro/nano-bubble related research: current trends, present application, and future prospects. *Scientometrics*, 53-71. <https://rdcu.be/djigi> <https://doi.org/10.1007/s11192-016-2004-4>

Exploratory-descriptive study of the most widely used programming languages in the software industry in Mexico. An educational approach

Estudio exploratorio-descriptivo de los lenguajes de programación más utilizados en la industria del software en México. Un enfoque educativo

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Abstract

Objectives: The objective of this study is to analyze the most used programming languages in the software industry in Mexico and their relevance from an educational perspective, recognizing the importance of training young people in technological and cognitive skills to prepare them for a world driven by technology. Methodology: The study was based on a survey applied to a probabilistic sample of 401 professionals working in the application development industry. The results of the study show that Mexican companies use the programming languages C# (28.3%), JavaScript (21.7%), Java (20%), and Python (10%), which contrasts with surveys at the global level where JavaScript is the most prevalent but coinciding with the top 5 of the most used languages worldwide. Contribution: The results contribute to understand which are the most popular languages in the country and allow to identify the most relevant tools to integrate in the educational programs, adapting to the demands of the labor market and promoting the learning of skills that boost the personal and professional development of the students.

ICT, Software, Education

Resumen

Objetivos: El objetivo de este estudio es analizar los lenguajes de programación más utilizados en la industria del software en México y su relevancia desde una perspectiva educativa, reconociendo la importancia de formar a los jóvenes en habilidades tecnológicas y cognitivas para prepararlos para un mundo impulsado por la tecnología. Metodología: El estudio se basó en una encuesta aplicada a una muestra probabilística de 401 profesionales que trabajan en la industria del desarrollo de aplicaciones. Los resultados del estudio muestran que las empresas mexicanas utilizan los lenguajes de programación C# (28.3%), JavaScript (21.7%), Java (20%), y Python (10%), lo cual contrasta con encuestas a nivel mundial donde JavaScript es el más preponderante, pero coincidiendo el top 5 de los lenguajes más utilizados a escala global. Contribución: Los resultados contribuyen a comprender cuáles son los lenguajes más populares en el país y permite identificar las herramientas más relevantes para integrar en los programas educativos, adaptándose así a las demandas del mercado laboral y fomentando el aprendizaje de habilidades que impulsen el desarrollo personal y profesional de los estudiantes.

TIC, Software, Educación

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Introduction

In today's educational landscape, programming languages have gained significant relevance due to their ability to enhance technological and cognitive skills in students. Mexico, like many other nations, has recognized the need to train its youth in these digital competencies, to prepare them for a world increasingly driven by technology and innovation.

In this context, it is essential to conduct a scientific study that analyzes the most commonly used programming languages in the Mexican tech industry and justifies their importance from an educational perspective. Understanding which languages are most popular in the country will allow for the identification of the most relevant tools to integrate into educational programs, thus aligning with the demands of the job market and promoting the learning of skills that boost students' personal and professional development. In this regard, Layedra *et al.* (2022) mention that the significance of such studies lies in providing students with training aligned with the languages most in use today, thereby equipping graduates with the skills needed to meet the current challenges inherent to their profession.

On the other hand, Tejera *et al.* (2020) state that in the quest to promote the essential skills and capabilities necessary to ensure real progress in technological education, it is vital to continue researching and delving into programming languages, to achieve genuine technological inclusion in educational settings.

The design of this study will be based on the application of a survey to professionals currently working in the field of application development. The main goal is to gather pertinent information regarding the programming languages most used by these professionals, as well as their opinion on the relevance and benefits that the knowledge of these languages offers in their professional development and in the evolution of their respective industries.

The survey was meticulously crafted by experts and addresses fundamental aspects, such as familiarity with programming languages, mastery level, practical applications in the workplace, and associated professional growth opportunities.

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Through this data, a clear view of the demands and needs of the Mexican work environment in terms of programming skills is obtained.

The results of this survey will be crucial to support the study of didactic techniques of the most relevant programming languages in the industry. By understanding the most sought-after languages in the workplace, educational institutions and teachers can adjust their academic programs and offer training more in line with the actual market needs. This will enable students to be more effectively prepared for a successful work future. Additionally, the survey results will provide a solid foundation for decision-making concerning curriculum design and planning of programming language training programs in Mexico.

Methodology

A descriptive and exploratory study was conducted.

Study Population: Economically active population belonging to industries related to computer science and information and communication technologies (760,200) as per data from the National Institute of Statistics and Geography (INEGI, 2020).

Time Frame: Period between February and May 2023.

Exclusion criteria: Incomplete or incorrectly filled out questionnaires.

A probabilistic sample was obtained with a type of simple random sampling, where the sample size was calculated using a 95% level and a margin of error of 5%, resulting in a total of at least 385 people.

The sample size is obtained from INEGI data in its press release No. 426/20 on statistics regarding individuals trained in computer science and ICT in Mexico, where it is estimated that 418,000 people are economically active professionals or technicians (INEGI, 2020).

To obtain the participation of such a large number of people, networking played a crucial role in obtaining the 388 surveys. Through the building and maintaining of professional relationships by the authors, dissemination on social networks (LinkedIn, Facebook, Instagram), direct email contact, and strategic alliances with teachers from other universities, a broad audience was reached, and the necessary participation was obtained.

The questionnaire was self-administered and distributed to participants using an online data collection platform (Google Forms).

The instrument used in this research consisted of a 14 multiple-choice question questionnaire. These questions were divided into sections. The first section covers sociodemographic variables, such as gender, work mode, the state where the company headquarters is located, and the place of work where professional activity is carried out.

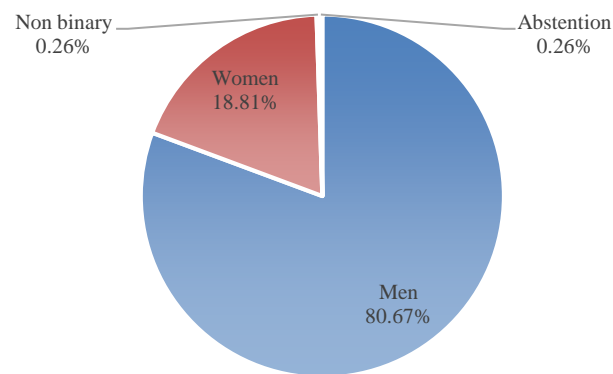
The second section is about the main objective of the survey, which is to determine which programming languages/frameworks are most commonly used in their daily professional activities and the experience they have with these technologies.

A third section includes exploratory questions about secondary tools that support software development tasks, such as database engines and cloud platforms for hosting and implementing applications.

For the construction of the statistical analysis proposal, the SPSS software package version 25.0 was used. Central tendency measures were used for the sociodemographic study variables and variables regarding the use of programming languages in Mexican companies.

Results

A total of 443 individuals participated in the study. However, 55 forms were excluded due to incorrect or incomplete filling. Of the remaining 388, 80.79% (313) were men and 18.7% (73) were women, 1 participant identified as non-binary gender, and 1 chose not to share this information.

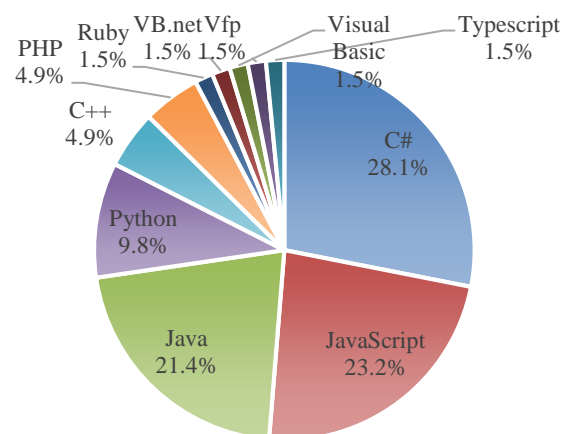


Graphic 1 Percentage of participation by gender
Source: Author's Own Creation

The states of the republic where the main offices or headquarters of the companies of the respondents are located were: Jalisco (18%), Nuevo León (15%), Coahuila (15%), Durango (10%). The remaining states accounted for the rest of the distribution percentage.

The average age of respondents was 29.61 years. Half of them answered that their position has a direct relationship with application programming (51.6%), while 15% hold a leadership position or project management role. 65% of them reported that their work mode is in-person, with the remainder reporting that they work remotely.

Regarding the programming language most used in their daily activities, the top 5 were: 28.1% reported using the C# language, followed by JavaScript at 23.2%, Java at 21.4%, and Python at 9.8%.



Graphic 2 Most used programming languages in the industry
Source: Author's Own Creation

More than half of the participants (50.11%) answered that they have intermediate experience (between 1 and 3 years) in the programming language they use for their work.

When asked why they believe the company uses this programming language, with multiple options to choose from, it stands out that the main reason is its wide availability of libraries and frameworks, with 78.3% of the responses, followed by its efficiency and performance with 56.7%.

Regarding the most used framework related to the main programming language, 26.7% answered that they use one of the two versions of asp.net (asp.net, asp.net Core), followed by React with 16.7%, and node.js with 10%.

In relation to the exploratory questions, when asked about the database engines used, most of the respondents use Microsoft SQL Server (53.3%), followed by MySQL (23.3%) and Oracle Database (13.3%). Regarding the most used cloud platform, 46.7% of the answers mentioned AWS, followed by Microsoft Azure, and in third place, Google Cloud (18.3% and 13.3%, respectively).

Discussion

This study, conducted on workers in the software development industry, allows us to observe that Mexican companies mainly use the C# programming language, accompanied by the asp.net and asp.net Core frameworks, followed by the JavaScript programming language, jointly using the react.js and node.js libraries.

The first-place contrasts significantly with prestigious global surveys, such as the one conducted by the Stack Overflow organization. This is an annual survey aimed at the global community of software developers, seeking to collect information on various aspects of the industry and trends in the field of programming. In it, the most used programming language globally by professionals is JavaScript, while C# is relegated to the seventh position (StackOverflow, 2022).

On the other hand, the cloud-based software development platform, GitHub, through its annual report analyzing data and trends within its GitHub Octoverse platform, reports, like Stack Overflow, that the most used programming language is JavaScript, relegating C# to fifth place (GitHub, 2022).

However, this language has shown steady growth over the years. Remember that GitHub is a platform that allows developers to host, review, and collaborate on open-source and private projects. It provides version control tools and facilitates teamwork by allowing developers to collaborate on the same project simultaneously.

When comparing the results with other scientific studies, such as the one conducted in Ecuador by Layedra *et al.*, (2022), it is concluded that both C# and JavaScript are languages that have consolidated their position over time in the field of web and mobile development. These languages show potential to continue evolving and meeting the development needs of professionals in this area.

Meanwhile, in Spain, the most in-demand programming languages are (in order of relevance) Java, Python, JavaScript, C++, C#, PHP, C, and Swift (Romero, 2021).

Acknowledgement

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This project was not supported by any source of funding.

Conclusions

While the results obtained by the study radically contrast C# as the main language of companies, it also shows a clear trend in the use of JavaScript as the primary language, without neglecting coincidences in the ranking of languages like Python and Java.

It can be concluded that today, it is of great importance for educational centers in Mexico to focus the planning of their programs on these languages to facilitate students' early and rapid integration into the working world. It is also considered essential to continue researching and deepening the current study topic to achieve effective technological inclusion of programming languages in educational environments according to the future needs of the industry.

To move in this direction, we suggest exploring new research lines that combine programming languages with other methodologies and resources such as gamification, augmented reality, and robotics.

Following the educational line, it is suggested that universities implement programs aimed at the use of MS SQL or MYSQL databases, also incorporating the use of cloud platforms such as AWS, Microsoft Azure, and Google Cloud.

This study also reveals the gender inequality that exists in companies regarding ICT personnel, recording only an 18.7% participation by women. It is strongly suggested to investigate this phenomenon, its causes, and consequences, to promote inclusion and diversity in the ICT field.

References

- GitHub. (2022). *The top programming languages*.
<https://octoverse.github.com/2022/top-programming-languages>
- Instituto Nacional de Estadística y Geografía. (2020). *Estadísticas a propósito de las personas formadas en las ciencias de la computación y las TICS en México. Datos nacionales. Comunicado de prensa Núm. 426/20*.
<https://www.inegi.org.mx/contenidos/saladeprensa/aproposito/2020/FormacionTIC.pdf>
- Layedra Larrea, N. P., Ramos Valencia, M. V., Salazar Cazco, S. A., y Baldeón Hermida, B. A. (2022). *Análisis de los lenguajes de programación más utilizados en el desarrollo de aplicaciones web y móviles. Domino De Las Ciencias*, 8(3), 1601–1625.
<https://doi.org/10.23857/dc.v8i3.2889>
- Romero, F. (2021) *Habilidades técnicas más demandadas en España en 2021*. LinkedIn.
<https://www.linkedin.com/pulse/habilidades-técnicas-más-demandadas-en-españa-2021-romero-garcía/?originalSubdomain=es>
- Stack Overflow. (2022). *Stack Overflow Developer Survey*.
<https://survey.stackoverflow.co/2022>
- Tejera Martínez, F., Aguilera, D., y Vílchez-González, J. M. (2020). *Lenguajes de programación y desarrollo de competencias clave, Revisión sistémica*. Revista Electrónica de Investigación Educativa, 22, 1–12.
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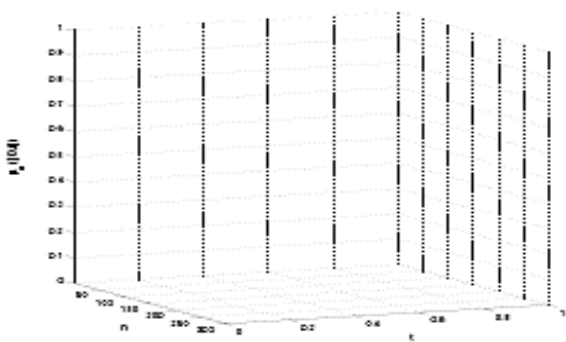
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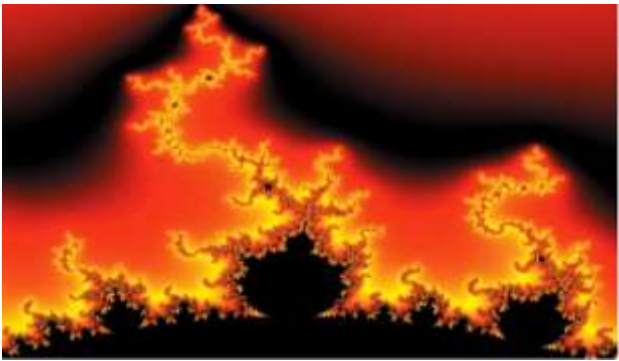


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