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Journal of Technology and Education

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Support the international scientific community in its written production Science, Technology and Innovation in the Field of Engineering and Technology, in Subdisciplines Standards of digital skills for education, learning projects through the use of information and communication technologies, development of digital teaching skills, digital skills programs, management of technological and educational consultancy, technological training fields applied to education.

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The works must be unpublished and refer to topics of Standards of digital skills for education, learning projects through the use of information and communication technologies, development of digital teaching skills, digital skills programs, management of technological and educational consultancy, technological training fields applied to education and other topics related to Engineering and Technology.

Content Presentation

As first article we present, *Mobile application with augmented reality applied to programming learning*, by SÁNCHEZ-JUÁREZ, Iván Rafael, PAREDES-XOCHIHUA, María Petra and MORALES-ZAMORA, Vianney, with adscription in the Tecnológico Nacional de México campus San Martín Texmelucan, as second article we present, *Towards the development of functional technological units in the academic area of computing and electronics*, by POZAS-CÁRDENAS, Mariano Javier, HERNÁNDEZ-SÁNCHEZ, David, CURIEL-ANAYA, Arturo and TORRES-SAMPERIO, Gonzalo Alberto, with adscription in the Universidad Autónoma del Estado de Hidalgo, as the third article we present, *App 4LG3BR4 a tool for learning basic Algebra in students of Information and Communication Technologies*, by TREJO-TREJO, Gilberto Abelino, DOMINGUEZ-GUTU, Jesús, CONSTANTINO-GONZALEZ, Fernando Exiquio and GORDILLO-ESPINOZA, Emmanuel, with affiliation at the Universidad Tecnológica de la Selva, as last article we present, *Educational software for teaching mathematics to first grade primary school children with hearing impairment in .NET framework*, by GONZÁLEZ-AMBRIZ, Rosalba, SAMPAYO-RODRÍGUEZ, Carmen Jeannette, GONZÁLEZ-MARTÍNEZ, Blanca Areli and MARTÍNEZ-SANTOS, Jesús Alberto, with affiliation at the Tecnológico Nacional de México/Instituto Tecnológico Superior de Huauchinango.

Content

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Mobile application with augmented reality applied to programming learning

Aplicación móvil con realidad aumentada aplicada al aprendizaje de programación

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Abstract

Augmented Reality (AR) is a technology that allows users to have interactive experiences between themselves, the physical world, and the virtual world through the use of digital devices that have a digital camera, such as smartphones, tablets, desktop computers, or laptops. AR has various applications such as entertainment, advertising and marketing, medicine, architecture, engineering, tourism, e-commerce, or education; in the latter, students can visualize different concepts of programming fundamentals or object-oriented programming. The objective of this project is to create a mobile application applying augmented reality to the fundamental concepts of programming so that students can improve their understanding and retention of syntax and examples of terms used in Java. The application is focused on control structures, conditionals, classes, methods, constructors, objects, and arrays. Searching for concepts on the internet, physical or electronic books, or even with classmates, can take up to 5 minutes, with this application, it is possible to see the structure and/or examples in a matter of seconds, besides having the advantage that it does not require internet connectivity.

Arrays, Augmented reality, Sintax

Resumen

La realidad aumentada (AR) es una tecnología que permite a los usuarios tener experiencias de manera interactiva entre él, el mundo físico y el mundo virtual mediante la utilización de dispositivos digitales que cuenten con una cámara digital, tales como smartphones, tablets, computadoras de escritorio o laptops. La AR tiene diversas aplicaciones como entretenimiento, publicidad y marketing, medicina, arquitectura, ingeniería, turismo, comercio electrónico o educación; en esta última, los estudiantes pueden visualizar diferentes conceptos de fundamentos de programación o en la programación orientada a objetos. El objetivo de este proyecto es crear una aplicación móvil aplicando la realidad aumentada a los conceptos fundamentales de programación con la finalidad que los estudiantes puedan mejorar su comprensión y retención de sintaxis y ejemplos de los términos que se manejan en Java. La aplicación está enfocada a ciclos de control, condicionales, clases, métodos, constructores, objetos y arreglos. La búsqueda de los conceptos en internet, libros físicos o electrónicos, incluso con compañeros de clase, puede llegar a tardar hasta 5 minutos, con ésta aplicación es posible ver la estructura y/o ejemplos en cuestión de segundos, además de tener la ventaja que no necesita conectividad a internet.

Arrays, Realidad aumentada, Sintaxis

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Introduction

In 2021, the National Survey on Availability and Use of Information Technologies in Households (ENDUTIH) was conducted, revealing that 91.7 million people have cell phone service, with 93.4% of them being internet users in the 18 to 24 age range, which includes university students. For this reason, the majority of university students have a smartphone that supports them in their school activities.

Around 226 out of 254 campuses of the Tecnológico Nacional de México offer the degree program in Computer Systems Engineering, where subjects such as Fundamentals of Programming and Object-Oriented Programming are taught. These subjects serve as the foundation for programming. However, many students struggle to understand the syntax of basic instructions in the Java programming language, such as the structure of a class, the for or while loop, among others.

To help them better comprehend these terms, a mobile application with augmented reality is created. When the marker is read within an editor like NetBeans, it will display the syntax of the instruction. This will save time that would otherwise be spent searching for it on various internet websites. Additionally, the application can display the syntax in a language other than Java, thus avoiding confusion. The application will be able to identify 16 different instructions and provide relevant information for each of them.

Unlike tutorials, physical or electronic books, or websites, this application will be able to identify the marker (word) and display the syntax with information in less than 3 seconds. Furthermore, it does not require an internet connection.

Theoretical Framework

Augmented Reality (AR) enables the interaction between virtual environments and the physical world, allowing them to blend together through a technological device such as webcams, mobile phones (iOS or Android), tablets, among others.

In other words, AR inserts virtual objects into the physical context and presents them to the user using the interface of the real environment with the support of technology (Grapsas, T. 2019).

Augmented reality is classified into: Image recognition-based augmented reality: It does not require markers or patterns to activate the process. The images themselves serve as signals that trigger the method, where the virtual content is placed on top of them.

Geolocation-based augmented reality: It relies on the user's location being at a point of interest, and then visualizing relevant information on the device's screen.

Pattern recognition-based augmented reality: This type of augmented reality involves the use of markers (targets) to activate virtual content (KeepCoding Team. 2022).

For the implementation of this project, pattern recognition-based augmented reality (markers or targets) will be used. These markers will be images representing the instructions to be reviewed, such as "for," "if," "switch," or classes.

As expressed by ConversusTV in an interview with Dr. Jorge Toro González: "Education 4.0 (E4.0) applies Information and Communication Technologies to education in order to prepare people for the 4th Industrial Revolution (4IR); accessible to individuals at any educational level, to facilitate continuous learning and updating according to industrial, service, and business needs" (ConversusTV, 2019, 0m35s).

Augmented reality, like Education 4.0, is closely linked, allowing the integration of information and communication technologies with the visualization of three-dimensional objects in a real environment. This can lead to m-learning (mobile learning), which is learning based on mobile devices. The key characteristic is that educational applications can be installed on mobile phones and accessed anytime, making use of the time students have during their commute from home to school. As mentioned by García-Bullé (2019), m-learning content often promotes informal learning to acquire skills such as emotional intelligence or problem-solving. Therefore, using augmented reality in education will encourage student learning.

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Methodology

The activities carried out for this project are: analysis of the elements to be generated, design of 3D elements, design of markers, creation of the Vuforia database, configuration of Vuforia with Unity, asset importation to Unity, application generation, and finally, testing. The Vuforia Target Manager is a web-based tool that enables you to create and manage target databases on Vuforia's developer portal. (Vuforia, 2023)

Analysis of the elements to be generated: A survey was conducted to determine which instructions students find most complex to understand in terms of their functionality or syntax. The survey also aimed to investigate the time it takes for students to search for the structure or example of programming instructions in Java, as well as the most common means they use to search for instruction structures.

Out of 16 instructions, the most complex syntax, ranked first, is the foreach loop with 57.1%. Matrices rank second with 46.4%, and methods, arrays, and lists share third place with 35.7%. 50% of the surveyed students take 2 to 5 minutes to search for instruction structures, 28.6% take over 10 minutes, 14.3% take 6 to 10 minutes, and only 7.1% take less than 1 minute to find the information. Finally, 82.1% search on web pages, 10.8% use PDF files, and 7.1% consult with a classmate. Figure 1 shows the results of the time it takes for students to search for an instruction.

Figure 1 Search Time Results
Source: Own elaboration

Design of 3D elements:

The next stage is to design the various elements that will be displayed in 3D. These elements include: main, class, methods, constructor, for, foreach, while, do while, id, if...else, switch, vectors, matrices, lists, objects, and data types.

The software used for the design is Blender 3.3.0. The files can be generated with the .blend or .dae (Collada, an exchange format for 3D applications and the format for 3D objects with textures) extensions. In this stage, colors, positions, sizes, or transformations are assigned to each object. COLLADA, which stands for COLLAborative Design Activity, is an open standard XML format for storing 3D models (ArcGis, s.f.). Figure 2 shows the design of the structure of a Java class.

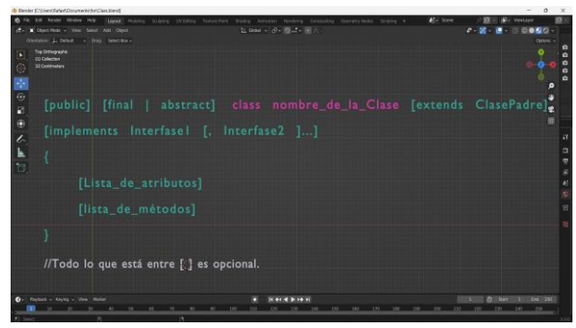

Figure 2 Class Structure Design
Source: Own elaboration

Marker design:

Augmented reality applications based on markers utilize target images (markers) to position objects in a specific space. These markers determine where the application will place the 3D digital content within the user's visual field.

Early-stage augmented reality technologies relied on markers (Softtek, 2022). To ensure good quality markers, the following characteristics must be met: grayscale images of 8-bit or RGB images of 24-bit in JPG or PNG file format are allowed. Failure to meet these characteristics will result in an error when uploading the markers (targets) to Vuforia.

Markers are detected based on their printing size and the distance given from the device's camera. It is recommended that the larger the marker's print size, the greater the distance from which the camera can detect the object. Table 1 shows the marker sizes and the detectable distances.

Size	Distance
16 * 16 cm.	1.9 m.
11 * 11 cm.	1.3 m.
7.5 * 7.5 cm.	1.0 m.
3.5 * 3.5 cm.	0.4 m.
1.3 * 1.3 cm.	0.16 m.

Table 1 Marker sizes and distance
Source: Adapted from Ministerio de Educación del Gobierno de la Ciudad de Buenos Aires (s.f.)

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Creating the Database in Vuforia: Vuforia Target Manager is a web-based tool that allows you to create and manage target databases on the Vuforia developer portal. Targets are assigned a star rating based on their quality. The star rating influences the robustness of the target in terms of detection and tracking.

The star rating can range from 0 to 5 stars. A higher rating is better because it indicates that the image target provides easier detection and more stable tracking. Vuforia Engine can only detect a target if it has a rating of at least 1 star. Targets with a rating of 0 stars cannot be used. If the database contains targets with 0 stars, they should not be selected when downloading the database. (Vuforia, 2023)

After generating the markers, it is necessary to create a database that contains all the targets. Each target in the database should have a rating of 3 to 5 stars, in addition to meeting the specified characteristics in the marker design phase. As shown in Figure 3, the targets are rated from 3 to 5 stars.

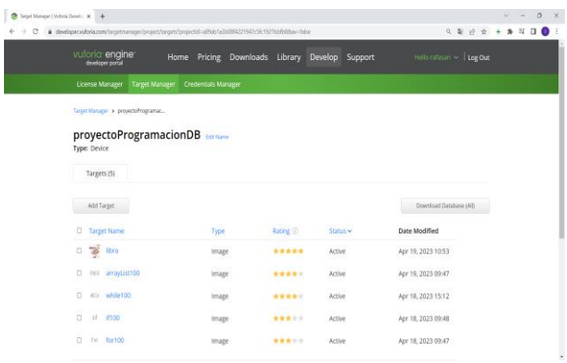

Figure 3 Target Ratings
Source: Own elaboration

Please refer to the table 2 below for the target ratings:

Target Rating	Description
1 star	Basic target quality
2 stars	Fair target quality
3 stars	Good target quality
4 stars	Very good target quality
5 stars	Excelent tagret quality

Table 2 Target ratings
Source: Own elaboration

Vuforia Configuration with Unity: Once the previous steps have been completed, a license key must be generated from the Vuforia website in order to enable Vuforia Engine features in the mobile application.

Likewise, the "add-vuforia-package-10-10-2.unitypackage" file must be downloaded to implement the tools that support augmented reality with Vuforia in Unity, including AR-Camera and Image Target. After adding the AR-Camera to the Unity scene, the license key must be added in the Vuforia Engine configuration section. Finally, the database containing all the targets should be downloaded from Vuforia, and it will have the .unitypackage extension, allowing it to be imported into the Unity project. Figure 4 shows the Unity scene with targets and the Vuforia key.

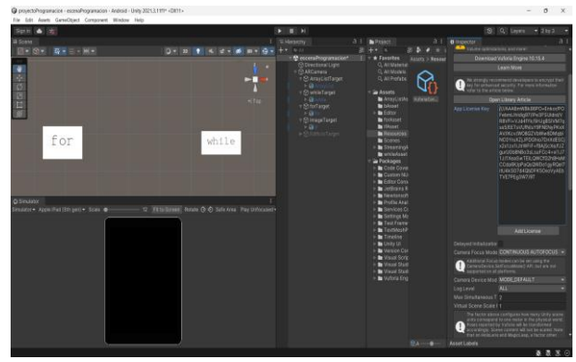

Figure 4 Vuforia configuration with unity
Source: Own elaboration

Importing Assets to Unity: With the AR Camera and the database ready, the image targets were added to the scene. Each image target must be associated with an image that serves as the previously designed marker. When this marker is placed in front of the device's camera, it allows the visualization of the 3D object. Once each target is ready, the assets, which are the elements created in Blender, are added. Each element is overlaid on the corresponding image target where it should appear. Figure 5 shows the inclusion of the "for" loop asset within its image target, which is located within the AR Camera.

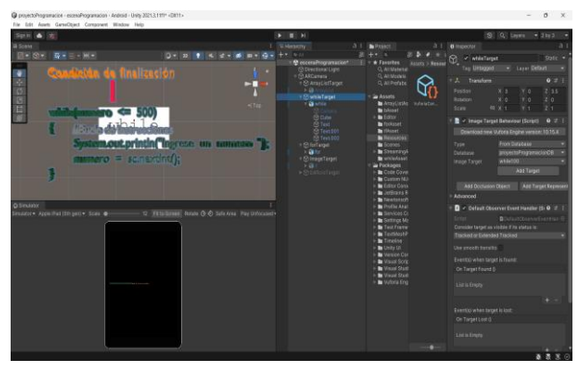

Figure 5 "For" loop asset in Unity
Source: Own elaboration

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Generating the application: Once the Unity scene is finalized, it's time to generate the application file for the mobile device. The following parameters need to be configured: company name, product name, version, default icon, and setting the Minimum API Level to Android 9.0 'Pie' (API Level 28). When performing the application build, the application name is set and saved on the phone for execution. Figure 6 shows the Player settings configuration of the application to generate the APK file that will be installed on the smartphone or tablet.

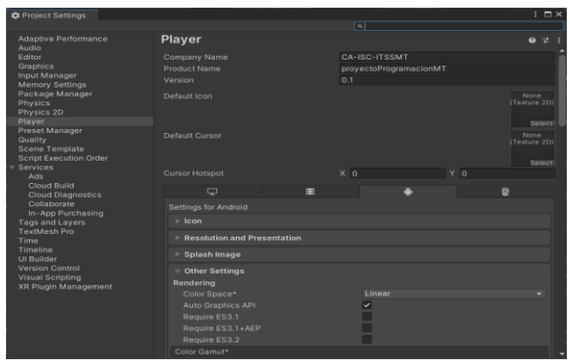

Figure 6 Player settings configuration
Source: Own elaboration

Results

At the end of the project stages, the application was installed on the smartphones of students and teachers. Tests were conducted with the programming instructions mentioned in the "Design of 3D Elements" stage. Figure 7 shows an example with the syntax of the conditional statement "if". The application detects the "if" marker, which can be read in the NetBeans 8.2 IDE. In the example, the boolean condition and the code block are highlighted if the condition is met.

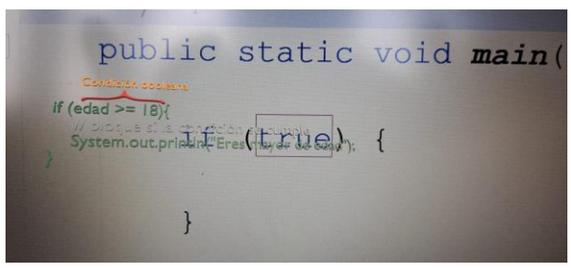

Figure 7 AR applied to the "if" statement in Java
Source: Own elaboration

Another marker that it detects is for the "for" loop, it will show the way to initialize the loop, the stop condition, and the increment, followed by the code block to be executed. Figure 8 shows the execution of marker detection.

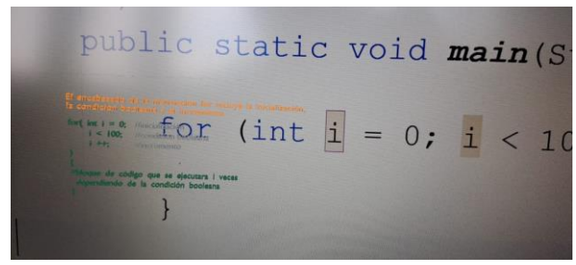

Figure 8 AR applied to the "for" statement in Java
Source: Own elaboration

Similarly, when reading the "while" loop instruction within the NetBeans editor, the application displays its structure and a practical example. Figure 9 shows the detection of the marker and the augmented reality for the "while" loop.

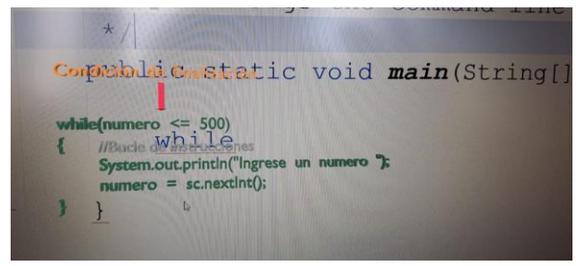

Figura 9 AR applied to the "while" statement in Java
Source: Own elaboration

Finally, the detection of the word (marker) "ArrayList" is shown, along with an example of how to create a generic ArrayList and add elements of different data types to it. The declaration of an ArrayList specifying its data type, such as Integer or String, is also demonstrated. Figure 10 shows the application in execution with the detection of the ArrayList.

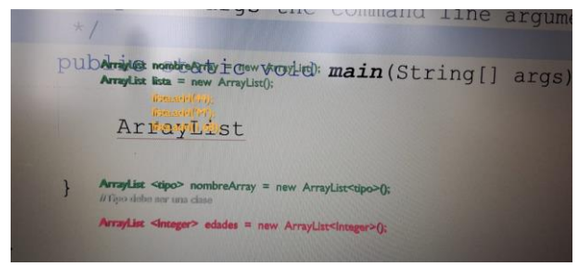

Figura 10 AR applied to the "ArrayList" instruction in Java
Source: Own elaboration

The application detects the markers within a range of 3 to 5 seconds and displays the desired information based on the selected instruction, significantly reducing the time spent searching through websites or electronic files.

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Tests were conducted with students from the 2nd and 4th semesters of the Computer Systems Engineering program. For the application to work properly, it is recommended to have a phone with a camera resolution of at least 8 megapixels.

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Financing

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Conclusions

By using this application, it becomes easier for students studying Computer Systems Engineering or related fields to search for the most common programming instructions. It saves search time, eliminates the need for internet access, and detects various programming instructions in a matter of seconds within a single application.

As a future work, the application can be uploaded to the virtual store so that any student in the country can have access to it, taking advantage of the benefits offered by mobile-based education (m-learning).

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Towards the development of functional technological units in the academic area of computing and electronics

Hacia el desarrollo de unidades tecnológicas funcionales en el área académica de computación y electrónica

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Abstract

The objective of this project is to show the feasibility of systematizing some of the administrative activities of the electronics laboratory and computer classrooms in the Academic Area of Computing and Electronics (AACyE), where its main activity is teaching and research, to move towards more functional work units with the use of technology, which we will call Functional Technological Units. In the present work the conditions in which the technological work units are stagnant due to not having adequate information management are described in an introductory manner. The methodologies used for the development of this research were based on the Organizational Development model and the use of agile methodologies such as XP, ERP or WSDM. As a result, two developments of web-oriented systems validated by the ISO 9126 standard and making a qualitative weighting based on the Likert scale are shown. As for the discussion, it focuses on collaborative work and the creation of a synergy between students, teachers and administrative staff. The results that were obtained have allowed administrative processes to be carried out with greater efficiency, impacting on the teaching, administrative work and the training of students in the AACyE.

Organizational development, Agile development methodologies, Strategic planning, Functional technology unit

Resumen

El objetivo de este proyecto es mostrar la factibilidad de sistematizar algunas de las actividades administrativas del laboratorio de electrónica y aulas de cómputo en el Área Académica de Computación y Electrónica (AACyE), en donde su principal actividad es la docencia y la investigación, para transitar hacia unidades de trabajo más funcionales con el empleo de la tecnología a las cuales les denominaremos Unidades Tecnológicas Funcionales. En el presente trabajo se describe en forma introductoria las condiciones en que las unidades tecnológicas de trabajo se encuentran estancadas por no tener un adecuado manejo de información. Las metodologías utilizadas para el desarrollo de esta investigación se basaron en el modelo de Desarrollo Organizacional y la utilización de metodologías ágiles como XP, ERP o WSDM. Como resultado se muestran dos desarrollos de sistemas orientados a la web validados mediante la norma ISO 9126 y haciendo una ponderación cualitativa basada en la escala de Likert. En cuanto a la discusión esta se centra en el trabajo colaborativo y la creación de una sinergia entre estudiantes, profesores y personal administrativo. Los resultados que se obtuvieron han permitido realizar los procesos administrativos con mayor eficiencia impactando en el quehacer docente, administrativo y la formación de estudiantes en el AACyE.

Desarrollo organizacional, Metodologías de desarrollo ágil, Planeación estratégica, Unidad tecnológica funcional

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Introduction

Productive institutions or service providers face multiple challenges every day. They try to achieve goals that reflect constant or sustained growth, which allows stability and harmonious coexistence in healthy work environments. Most people want to be integrated into environments where there is respect, collaboration and professional development. Notwithstanding, they are frequently part of organizations where there is regularly inadequate planning, deficient management, lack of control, and diminished execution in projects, and all this just leads to cyclical failures. They almost never excels and because of this, the Organizations have greater restrictions. The same behavior is followed by some higher education institutions. Regularly the information systems that operate are insufficient or work in isolation, some departments such as school control work well, provide agile services to students supported by computerized systems, but it is not the only department that requires control of information. There is also a demand for information and on several occasions it is duplicated. There is no innovation. There is work saturation in teachers and sometimes certifications are compromised by restrictions on subsidies or support for the investigation.

The question that arises is: how can work areas be supported and strengthened, in a chaotic situation, using basic computer knowledge as a discipline? Is it possible to create a Functional Technological Unit (UTF) in an Academic Area of Computing? Are there strategies that help us move towards a more productive work area?

Fortunately, yes, there are strategies and models that can help to survive and excel. One of these strategies is the use of the Organizational Development (OD) model, which contemplates the management and incorporation of knowledge (Sánchez, 2009), (Morillo and Suárez, 2011), combined with agile methodologies for system development, enhancing productivity without sacrificing quality (Delgado, 2021), (Bautista, 2022).

Organizational Development makes it possible to achieve a culture of development in which formal or informal knowledge, the talent of people, the use and exploitation of technological resources that are available to organizations, the application of new models or ways of working, as well as innovative proposals that allow faster transition to sustainable work areas, are privileged and promoted, (Finol de Franco, 2011).

The proposal in this project is the automation of the electronics laboratory and computer rooms after having carried out an analysis to identify their needs. Later, develop a system that allows achieving better efficiency in the services offered such as loan of materials, equipment and allocation of spaces for common use of the computer rooms, considering the limitations that usually exist in public education institutions, such as: budgetary restrictions for the administration, saturated modernization departments or scarce hiring of personnel to modernize the academic areas. The Hiring of personnel is mainly focused on teaching, little motivation on the part of teachers to get involved in development or automation tasks, since, in the first instance, there will only be more work and little recognition.

An important factor that must be considered is collaboration and teamwork. The participation and appreciation of the most important resource of a university, which are people. That is students and teachers mainly. The great potential they often have is not taken advantage of. students and are also denied the opportunity to participate in real and productive projects such as the development of information systems focused on solving the needs of an academic area or department. The activities must be under the supervision and direction of professors focused on the development of information systems, whether in final projects, theses, social service students or professional practices.

Although many of the final projects of the students are oriented to the development of educational materials or hypothetical cases. It is also feasible to orient projects to the development of applications in the administrative work areas of the department that facilitate the automation of information.

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Thus, promoting the availability of information at all times and in any place where there is internet and a computer fin such a way that the processes of access to information would be optimized. In this way, it would be moving towards a functional technological unit. We can mention large public and private corporate companies that take strategic planning seriously within their organizations, strengthening their technological units. For example, banking and government service institutions such as Google, Facebook, Santander, SAT, INFONAVIT, among others.

Methods used

One of the models that inspired the project to move towards the creation of a functional technological unit is the Organizational Development Model. Especially the creation of intelligent companies or institutions and knowledge management. The first is characterized by having information and knowledge available in an organized way providing multiple advantages when generating new knowledge, both for its workers and for its users and the second helps to create creative processes and environments, transfer and apply knowledge to be more productive This OD model can be synthesized in four phases which they were applied as follows (Sánchez, et all., 2017):

- Socialization, which allows the identification of the problem, through the participation of those in charge of the electronic laboratory and computer rooms who externalized the manual procedures of their services by written requests, as well as the control formats.

- Exteriorization, in this phase the ideas are organized in a group to know what is happening?, why?, how to solve it? and Who could be the actors that help solve the problem?

- Combination allows systems to be developed in various ways with diverse groups of students, teachers, and administrators.

- Internalization, after implementing the systems, the results are valued to improve the processes.

The use of the DO model allows the creation of synergy between the actors involved. It conduces to express problems that affect the functionality of the work areas and at the same time proposing creative ideas.

Several agile methodologies were also used, the ERP (Enterprise Resource Planning) methodology and the Xtreme-XP methodology. The ERP and XP methodology are based on continuous feedback between the client and the development team, fluid communication between all participants, as well as the simplicity of the implemented solutions.

The benefits for both developers and the company are:

- Speed and focus on development.

- Greater efficiency in the fragmentation and integration of development tasks.

- Easy access to the company's own information.

- Portability and Accessibility for all components of the organization.

- Elimination of unnecessary operations for the company or for the end user.

These methodologies are flexible and when applied they present quick results. Even though the complete idea of the project is imprecise, which allows alternative ideas to be proposed to a problem. For this reason, it is oriented towards the development of software for internal use of the organization. Some applications can be, warehouses and inventories, internal reports, finances, sales, human resources, development and analysis departments, manageable work areas, among others (Beck, & Andres, 2005).

Based on the principles of the Xtreme-XP rapid development methodology, we sought to enhance the interpersonal relationships of the development team and achieve continuous feedback between those in charge of the laboratory and the work team, achieving agility and flexibility in project management. Considering the scope of the project and the first delivery dates of the system, as well as the estimated time priorities in development (Arias, 2017).

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It was sought to obtain a first version in a short time that would serve as a basis to extend it. The work periods were four-monthly, since it was difficult to integrate or continue the project after the end of the school year of the students who made up the system development team.

Another of the methodologies used was the WSDM (Web Site Design Method), which refers to the method of designing a website, which consists of four phases.

- User model Phase.
- Concept design Phase.
- Implementation Design Phase.
- Implementation Design Phase.

Part of this methodology served as a reference for the design of the interfaces and the database, in such a way that it was easier for the user to manage the information (Molina, et all, 2017).

The use of the WSDM methodology stands out because it allows the development of the system in an orderly manner from the analysis, to the implementation and validation process, in such a way that the results of the developed application are shown. Also, to know if it meets the objective specific as well as the degree of approval by the user, knowing the possible errors and complications that could arise when interacting with the application, since a system must be validated and tested before its official presentation.

Next, a first project is described using the ERP (Enterprise Resource Planning) and Xtreme-XP methodologies, following collaborative and learning strategies through the solution of real problems of interest to companies or institutions.

Developing

The process carried out to generate the systems is described by applying the methodologies previously proposed, which have a very similar general structure, which is the identification of the problem, proposal, design, construction and implementation. Afterwards, both systems are described showing their characteristics in detail.

Problem

At the Autonomous University of the State of Hidalgo (UAEH) in the Institute of Basic Sciences and Engineering, there is a central electronics laboratory that provides service to various educational programs such as the Bachelor of Electronics Engineering (LIE), Bachelor of Telecommunications Engineering (LIT), Degree in Civil Engineering and Architecture (LICA), Degree in Computer Science (LCC) and occasional users of the UAEH from other degrees or high schools that request it.

The loan process has been carried out manually through the filling of loan vouchers, without this procedure representing a problem. However, it is believed that an automated system will speed up the loan process, improve control of the use of the equipment, propose a better planning and use of spaces for the realization of practices, as well as the reduction of operating expenses.

Proposal

It is proposed to develop an Administration System for the Loan of Materials and Equipment in the Electronic Laboratory (SAPMELE), which helps to digitize the operational processes of the Electronic Laboratory that guarantees a better operation for the users who are students, teachers and administrators. The system consists of two modules in its initial stage that will be in charge of satisfying the specific needs of:

- Loans.
- Inventories.

Design

During the design stage, the laboratory administrators and the project leader were in charge of communicating the needs of the laboratory to the team of programmers made up of a group of students. In this stage, two agile methodologies were used, the ERP (Enterprise Resource Planning) methodology and the Xtreme-XP methodology. The ERP and XP methodology, so that the entire work team collaborated in the design and development of the system. Table 1 list the main classes of the system and Figure 1, the use case diagram.

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Administration System Electronics Lab
- Users administration. - Practice management. - Materials' loans management. - Accesss control and users' permission. - Working areas and materials reservation.
- System administration use control () - Users' register () - Users' access accreditation () - Users' permission () - Practices' schedule and creation () - Areas assignation for booked practices () - Creation of materials reservation application () - Validation of materials existing on storage () - Autentication and validation of user's access () - Non booked areas and materials reservation (). - Storehouse creation (). - Materials and objects assignation (). - Permissions of storehouse access ().

Table 1 Main classes involved in the system

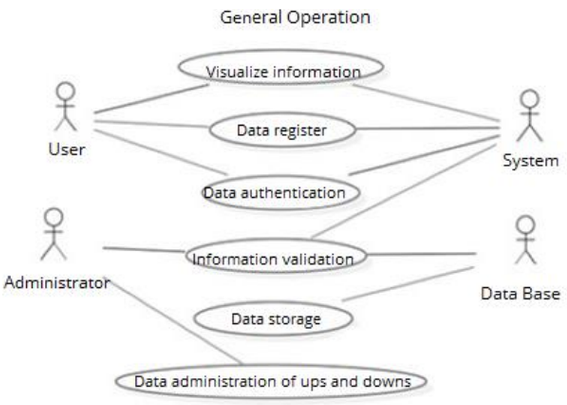

Figure 1 Use case diagram

Construction

The tools that were chosen for the development of the web-oriented system are:

- Laravel: PHP-based web development framework.
- JavaScript: allowed to develop the functionality of the system, as well as its configuration.
- HTML: View in any web browser.
- CSS: For designing system interfaces.
- PostgreSQL: Database manager.

Laravel

It was used since it is a cross-platform open source framework that allows the inclusion of functional tools such as libraries, plugins, designs, utilities to create views with Blade that can be integrated with PHP and Java code. Some of the general characteristics of these bookstores are (Arias, 2017):

- Blade-based templates.
- Fluent Requests.
- Composer-based.
- Cache support.
- MVC support.

Laravel facilitated the handling of events and authentication in addition to the robust support for the handling of the databases, the PostgreSQL database manager was used, where the different schemes, tables and data that make up the Laravel Laboratory project were implemented. Electronics.

Implementation

Once the development of the SAPMELE loan system was completed, it was implemented in the Electronics Laboratory. This serves as support for the entire university community, facilitating and streamlining the loan and inventory control processes, as well as reducing the costs of consumables and stationery. Below are some views of the SAPMELE loan system (Aguirre & Armenta, 2020).

Figure 2 shows the main view for the different types of users such as: students, administrators, teachers, social service providers; all of them access the system through a carousel.

Figure 3 shows the different options that a student has once they have entered, they can know and select the material available in the store, they can also know what is the material required for the practice they choose and finally in the option of the cart request the loan.

A partial list of materials or equipment available for your loan is shown in Figure 4.

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Figure 2 System main view

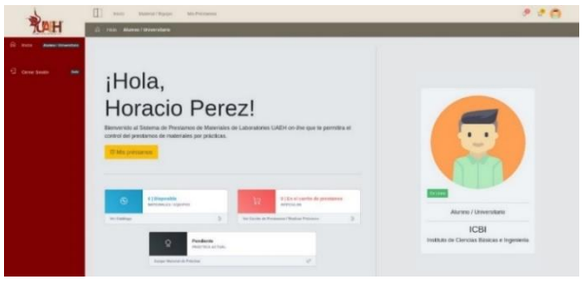

Figure 3 Consultation and loan options

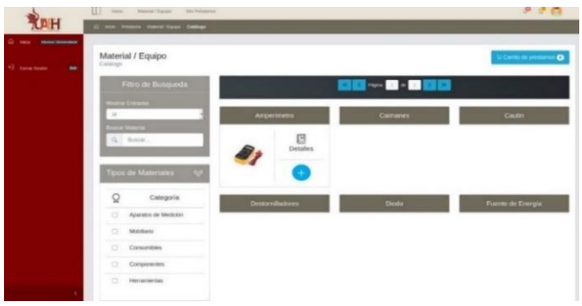

Figure 4 Materials catalog.

Next, a second project is described using the WSDM methodology, following collaborative and learning strategies through the solution of real problems.

Problem

There is a recurring problem in the Academic Area of Computing and Electronics (AACyE), which occurs during the registration and control of the use of the different classrooms, computer labs and spaces for common use. The registration of this information is always of manually and due to the number of teachers who enter and leave the class. This this process leads to limit the effective using time of the equipment and facilities on many occasions, as well as the lack of an agile space allocation process when there are unoccupied or unscheduled workspaces.

Another of the problems associated with the process of registering use and attendance manually, is the limited availability of information to follow up on equipment that stops working, is lost, or even student belongings that are left behind in the work areas.

The availability of information is reduced by the physical accumulation of record sheets or by the lack of record sheets, coupled with this, on many occasions the administrators are assigned different activities cataloged with higher priority, such as payroll among other.

Proposal

The creation of a Common Use Spaces Registration and Reservation System (SRREUC) is proposed, which optimizes the attendance processes, as well as the control of classrooms and computer labs and common use spaces, within the Computer Academic Area called SRREUC (Cruz, 2020).

The objective is that the application helps professors mainly to make the attendance registration process timely, avoiding crowds at the beginning of the different class hours. Moreover, it benefits the administrative staff, in the task of organizing and optimizing the use of computer labs and common use areas.

Design

This phase is one of the most important and for this the WSDM model was used as a basis, since it refers to the method of designing a website, since all the interfaces, methods and programming of activities are designed here. Also the roles of the users, the navigational design, as well as the use cases and the entity relationship diagram of the system are described. By respecting the framework of the methodology, it becomes a valuable guide to represent all the navigational and functional structures that developers will follow, which will benefit end users. Figure 5 shows the use case diagram that reflects the functions that the system administrator can perform, and figure 6 shows the class diagram, as well as their interrelationship between them.

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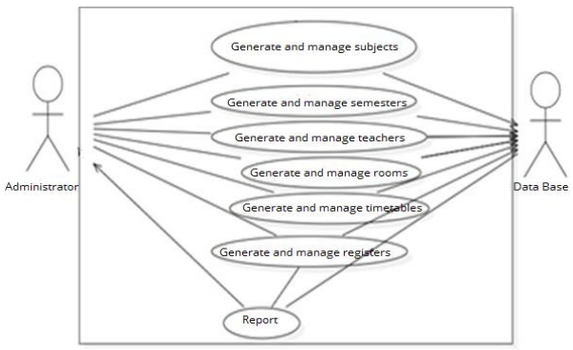


Figure 5 Use case diagram.

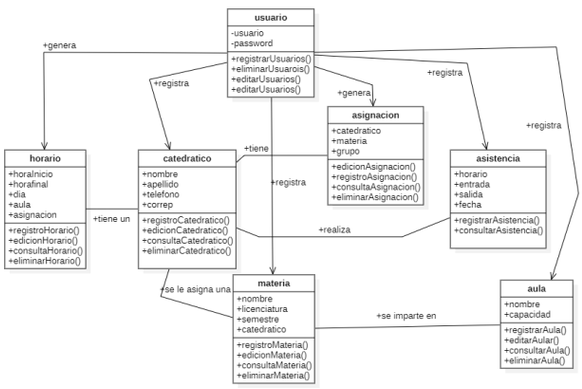


Figure 6 Class diagram

Construction

In this phase, the development environment Visual Studio Code and a set of tools called WAMP were used. By using the Apache module, a local server was enabled for the deployment of the web application. MySQL was also used as a database manager. A great Part of the system is developed in PHP for its flexibility and handling with the structure. It is also a language that works on the server side, this makes the processes even faster and the execution time of the programs is much less (Putier, 2015).

HTML was also used in conjunction with the CSS style sheet generator to create interfaces with the user, the entire layout of the web system, that is, the front-end, so that the system has a user-friendly design and that at its At the same time, take the style similar to any page or web application promoted by the University as a standard, since its main use would be for it.

Implementation

The system for the administration of the computer laboratories and spaces for common use, was implemented in a common access area in such a way that teachers can register and obtain information from the auditorium laboratories and work rooms to reserve them, if necessary, in a more agile and orderly way.

Below are some boxes that partially illustrate how the system works. For example, Figure 7, contains the menu with the login, check-in and check-out options, each button has a specific function. To illustrate, with the input button the teacher or user can register their attendance corresponding to a subject previously assigned at the beginning of the semester. In the same way with another button the end of use of the classroom or computer equipment can be registered and on the other hand we have the login that describes the different areas depending on the user that has been authenticated. Figure 8 shows the options that the administrator has to organize the work areas, and finally, Figure 9 shows an interface with the different options to obtain reports.

Figure 7 System main menu

Figure 8 Menu for the administrator Title

Figure 9 *Reports section*

Results

As a result of the application of the DO model. This allowed the creation of a proactive environment among the various members of the academic area that involves teachers, administrators and students. Apathy was broken, socialization led to the expression of various problems that affect the functionality of the areas of work and at the same time come up with creative ideas that led to the development of two web-oriented information systems.

A. Administration System for the Loan of Materials and Equipment in the Electronic Laboratory of the Institute of Basic Sciences and Engineering (ICBI)

B. System of Registration and Reservation of Common Use Spaces such as rooms, classrooms and computer laboratories within the academic area.

In each of the developments, the problem is raised, a solution proposal, its design, development and implementation.

Discussion

The proposals for innovation or alternative work model were encouraged to promote alternative changes, which promote work environments or more functional technological units supported with the most valuable resource, the human resources of a company or institution, as they are also in public universities.

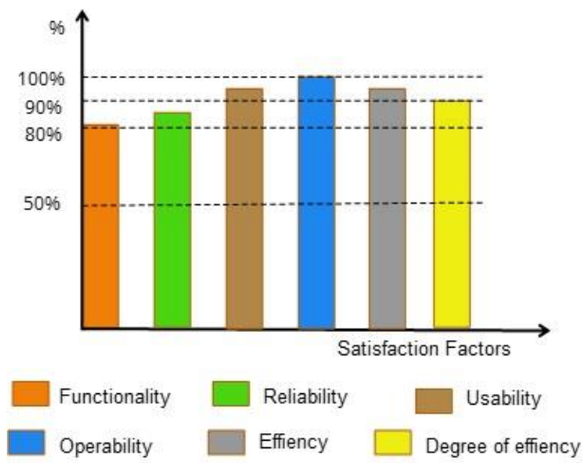
And, if the proposals are also socialized, shared, discussed and executed collaboratively, this action will allow us to plan with a global perspective, including monitoring all the actors involved. We will not only be solving a technical problem, but also moving towards a labor culture typical of advanced knowledge societies. This way we can reduce the generational gaps in the use of technologies.

Conclusions

Both systems were implemented and are working in their respective work areas, their validation is based on the metrics of the ISO/IEC 9126:2001 standard, and the McCall model (McCall & Cavano, 1978), which establishes various elements that must be evaluated, such as functionality, reliability, usability, efficiency, operability, maintainability, portability and satisfaction.

It should be noted that the information was collected through online Google forms applied to 120 users of the electronics laboratory and 45 teachers who use the commonly used computer rooms who answered after using the applications.

The results of the evaluations of the systems are shown in Graphs 1 and 2. A simple random statistical method was used, applying the Likert scale for the type of categorical variables used within the investigation (Méndez, 2007), the results of the evaluations will allow to improve the processes, thus facilitating a better management of the information that it handles the academic area.



Graphic 1 Evaluation result of the SAMPELE loan system

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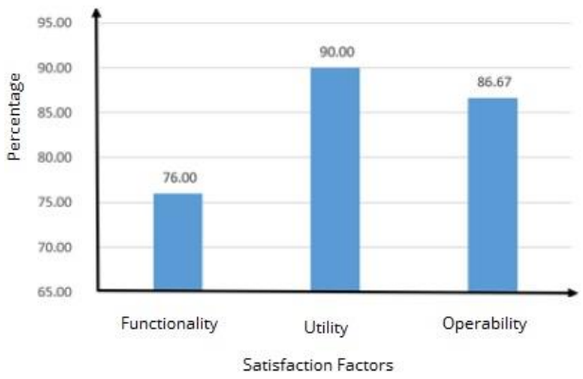

Graphic 2 Evaluation result of the SRREUC system

To achieve a functional technological unit. It is not enough to develop a couple of computer systems, which by themselves already provide operational advantages in information management. It is necessary to maintain the synergy of work, collaboration and socialization, a mature organizational culture that allows moving towards functional technological units within companies or institutions.

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App 4LG3BR4 a tool for learning basic Algebra in students of Information and Communication Technologies

App 4LG3BR4 una herramienta para el aprendizaje del Álgebra básica en alumnos de Tecnologías de la Información y Comunicación

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Abstract

Currently, technology has evolved and has been adopted in education, this is where another field opens up to analyze academic performance, now students do not interact with books or notebooks, they can do it with a Tablet, with a PC, a Smartphone or some other device that allows them to be interconnected; in this sense, the educational experience has different dimensions. Therefore, this research focused on the use of a mobile application for learning basic algebra, with the students of the Division of Information and Communication Technologies of the Technological University of La Selva. The study was carried out under a quasi-experimental quantitative approach, using tests designed with dichotomous answers (pre-test and post-test) as data collection tools. The results show that using the App 4LG3BR4 in the subject of Linear Algebra in the teaching and learning process, significantly increases the academic performance of students, compared to the traditional teaching of these subjects in the aforementioned subject.

Mathematics, Algebra, Application, Mobile

Resumen

Actualmente la tecnología ha evolucionado y se ha adoptado en la educación, es aquí donde se abre otro campo para analizar el rendimiento académico, ahora los alumnos no interactúan con libros o cuadernos, lo pueden hacer con una Tablet, con una PC, un Smartphone o algún otro dispositivo que les permita estar interconectados; en este sentido, la experiencia educativa tiene diferentes dimensiones. Por lo anterior, esta investigación se centró en la utilización de una aplicación móvil para el aprendizaje del álgebra básica, con los estudiantes de la División de Tecnologías de la Información y Comunicación de la Universidad Tecnológica de la Selva. El estudio se efectuó bajo un enfoque cuantitativo cuasiexperimental, utilizando como herramientas de recolección de datos, pruebas diseñadas con respuestas dicotómicas (pre-test y pos-test). Los resultados demuestran que usar la App 4LG3BR4 en la materia de Álgebra Lineal en el proceso de enseñanza y aprendizaje, incrementa significativamente el rendimiento académico de los estudiantes, comparado con la enseñanza tradicional de éstos temas en la materia mencionada.

Matemáticas, Álgebra, Aplicación, Móvil

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† Researcher contributing as first author.

Introduction

We are currently changing our way of facing everyday life and this is no exception for educational institutions, mainly in academic activities when applying the teaching and learning process.

After at least two years of confinement derived from COVID-19, educational institutions are facing the return of teachers and students to the spaces previously used for training activities (Linares-Morales, 2022), forcing the integration of Information and Communication Technologies (ICT) in teaching processes.

ICTs are immersed in practically all areas of human endeavor and, of course, in the educational area they cannot be absent. Portuguez (2021) mentions that technologies that are attractive to students and increase their interest in learning should be included. There are different technological tools that can be used to solve a problem and there are also different methods. Higher education seeks to implement ICT in the development of competencies (Herrera and Fennema, 2011), based on students' self-taught learning, using mobile devices as a support tool for learning inside and outside the classroom.

Mobile technologies, such as smartphones, tablets, and laptops, in addition to online applications and tools, became an integral part of most teachers' and students' lives worldwide (Drigas & Pappas, 2015). Kortabitarte, Gillate, Luna and Ibañez-Etxeberría (2018) states that, "the learner acquires a greater protagonist role, as mobile devices allow them to learn anytime, anywhere, self-regulate their learning" (p. 69). Araya (2007) mentions that, "the tasks proposed should awaken the student's interest. Those that present a certain degree of challenge are more attractive than those that are routine or easily solved" (p. 20).

Consequently, the development process of mobile applications for educational purposes should aim to respond to the needs of the educational environment and combine them as an intermediary in the teaching and learning process (Escobar-Reynel et al., 2021).

In recent years, mobile applications have been developed to support the teaching of various areas of mathematics, such as algebra, geometry, mathematical analysis, statistics, among others; these applications can help students improve their understanding of mathematical concepts and their problem-solving skills (Drigas and Pappas, 2015).

Kalloo and Mohan (2012), conducted an investigation to determine whether the MobileMath mobile application to learn algebra improved their academic performance, the data showed that it was significant for those who had already taken the subject of algebra in a previous period, but did not have a significant impact for those who were taking the subject for the first time.

Díaz (2017), conducted an investigation on the influence of algebra learning with the use of the GeoGebra application, the results show that the application influences algebra learning and recommends its use at all educational levels.

Arjona, Guerrero, Noh and Ay (2019), conducted a study to determine whether the mobile application developed supported the learning of the topic Algebraic Language, the application consisted of four didactic games, the results showed that 44.4% of the students found it difficult to learn with the application, it was accepted by the teachers of the mathematics area, however, they proposed observations for improvement.

Statement of the problem

At the Universidad Tecnológica de la Selva, before the pandemic caused by COVID-19, students enrolled in the first four-month period of technological careers had a high failure rate in the subject of Linear Algebra (see Table 1), due to the fact that "the understanding of concepts of Algebra has been the Achilles' heel of the students [...], where they apply arithmetic knowledge to solve problems [...], and the knowledge they acquire in previous educational levels is not enough to solve algebraic expressions or equations" (Domínguez-Gutú et al. , 2022, p. 2).

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Year	Students who took the course	Failed students in regular classes	Failure rate
2018	77	10	13.0%
2019	71	39	54.9%
Totals	148	49	33.1%

Table 1 Failure rate in the subject of Linear Algebra unit II
Source: (Domínguez-Gutú et al., 2022)

Consequently, the researchers made the decision to use the mobile application 4LG3BR4 developed by Domínguez-Gutú et al. (2022), as a support tool in the teaching and learning process of basic Algebra for incoming students in the three specialty areas of the Information Technology Division of the Universidad Tecnológica de la Selva.

Objective

The present research study aims to analyze the impact on the academic performance of students who used the mobile application 4LG3BR4 in the subject of Linear Algebra.

Methodology

According to Hernández, Fernández and Baptista (2014), this research was conducted under a quantitative approach, using a quasi-experimental design with an experimental group and a control group, with the independent variable being the use of the 4LG3BR4 App and the dependent variable being academic performance, for which the hypothesis "The use of the App 4LG3BR4 significantly improves the academic performance of first semester students of the technology careers of the Universidad Tecnológica de la Selva de Ocosingo, Chiapas, in the subject of Linear Algebra in the topics of basic Algebra" was proposed.

Sample

The sample of this study was non-probabilistic and intentional, and intentional, considering 101 students, 60 of them in the experimental group, of which 46 were males and 14 females; 41 in the control group, 30 males and 11 females.

Instrument

For data collection, a pre-test and post-test designed for the study were used, with dichotomous answers, in order to measure the academic performance of the students; the results obtained by the students in the tests were converted into scores with a scale from 0 to 10, in order to perform a statistical test for the difference of means.

To calculate the reliability of the dichotomous instrument, the Kuder-Richardson coefficient (KR20) was used with the statistical software RStudio Version 2022.07.01, yielding a value of 0.7 located in the High magnitude range (Ruíz, 2013), making it an instrument with an Acceptable reliability coefficient.

Development

The intervention carried out in the experimental group was designed with a didactic sequence, implemented through the following phases:

Initial phase.

The researchers designed the intervention using the mobile application 4LG3BR4, which was developed according to the thematic content of the Linear Algebra course taught in the 1st quarter of the ICT Division of the Universidad Tecnológica de la Selva.

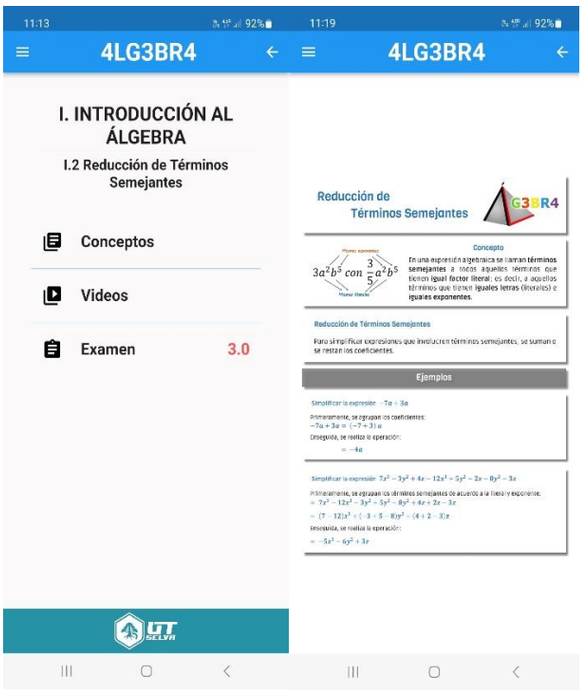

Figure 1 Part of the content of the 4LG3BR4 App
Source: Images from the research

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Intervention phase

Before carrying out the intervention, the pre-test was applied in both groups, in order to measure the previous knowledge they had in each of the basic Algebra topics; subsequently, in the control group, the teacher proceeded to develop the topics in the traditional way, in the experimental group the intervention designed for the study was carried out, where the students used the mobile application 4LG3BR4.

Figure 2 Intervention with the 4LG3BR4 App with the experimental group
Source: Images from the research.

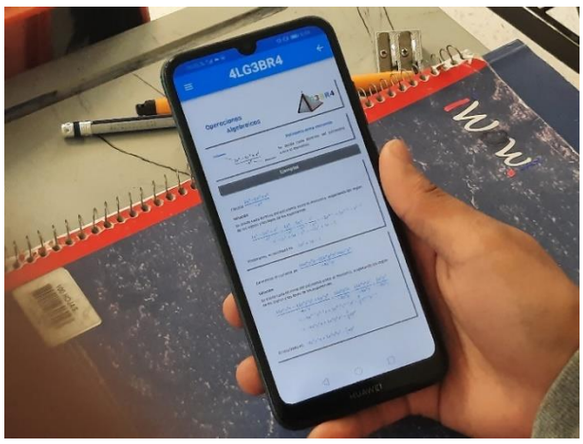

Figure 3 Student reviewing the infographic containing concepts and examples.
Source: Images from the research.

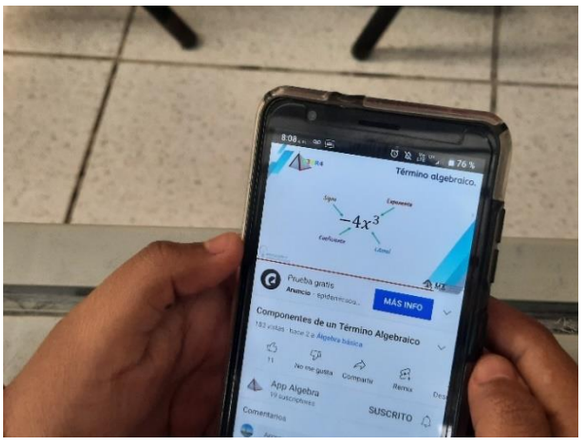

Figure 4 Student reviewing the exercise videos.
Source: Images from the research

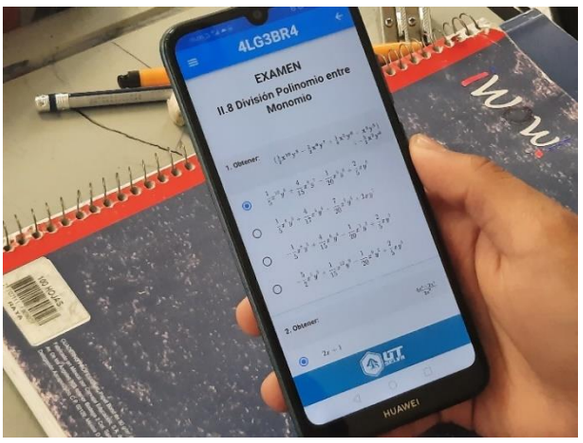

Figure 5 Student solving a test.
Source: Images from the research.

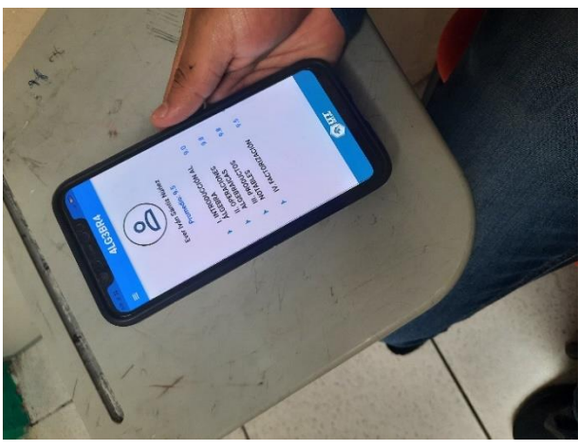

Figure 6 Student finishing the use of the 4LG3BR4 App.
Source: Images from the research.

Data collection phase

Once the intervention was completed, the post-test was applied to both groups to measure the academic performance acquired in the basic algebra topics.

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Results

To test the hypothesis of the research, the software RStudio Version 2022.07.1 was used, in which firstly, the normality test of the data was performed, obtaining a value of $p < 0.001$ for both groups, indicating that the data are not normal; consequently, the Mann-Whitney U test for independent samples was used, obtaining a value of p=0. 0012 which is less than the significance level $\alpha = 0.05$, therefore, the null hypothesis is rejected, i.e., the data support that there is a significant difference between both groups, accepting the hypothesis of the research.

Conclusions

The results obtained in the study show that using a tool such as the App 4LG3BR4 in the teaching and learning process, students obtain better results in their academic performance, compared to students who learn in a traditional way, therefore, to the teachers of the technological academic programs of this institution, the use of the App 4LG3BR4 is suggested as a didactic tool to support the teaching process in future generations; in addition, its use is recommended in other Institutions of Higher and Middle Higher Education.

Open lines of research

The completion of this study leaves open some lines of research to explore, such as the use of the App 4LG3BR4 with high school students, in semesters that include mathematics subjects that include the topics of Algebra.

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Educational software for teaching mathematics to first grade primary school children with hearing impairment in .NET framework

Software educativo para la enseñanza de las matemáticas en niños de primer grado de primaria con discapacidad auditiva en .NET framework

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Abstract

This article presents the results obtained from the development of an educational software made as a desktop application in .NET Framework for first grade children with hearing impairment to strengthen the learning of mathematics through the use of Mexican Sign Language; the research contributes to the SDG 5 Sustainable Development Goal of quality education and SDG 10 Reducing inequalities, sustainable development goals proposed by the United Nations. The agile software development methodology XP Extreme Programming was followed for project management, it was implemented with .NET Framework technologies, IDE Visual Studio and C# programming language, which allowed to obtain a quality software easy to implement and maintain.

Educational software, XP, .NET Framework, Visual Studio, C#

Resumen

En este artículo se presentan los resultados obtenidos del desarrollo de un software educativo realizado como una aplicación de escritorio en .NET Framework para que los niños de primer año de primaria con discapacidad auditiva fortalezcan el aprendizaje de las matemáticas a través del uso de la Lengua de Señas Mexicana; la investigación contribuye al ODS 5 Objetivo del desarrollo sustentable de educación de calidad y ODS 10 Reducción de desigualdades, objetivos de desarrollo sostenibles propuestos por las Naciones Unidas. Se siguió la metodología ágil de desarrollo de software XP Programación Extrema para la administración del proyecto, se implementó con las tecnologías .NET Framework, IDE Visual Studio y el lenguaje de programación C#, lo que permitió obtener un software de calidad fácil de implementar y mantener.

Software educativo, XP, .NET Framework, Visual Studio, C#

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† Researcher contributing as first author.

Introduction

The article presents the implementation process of an educational software designed and implemented under the requirements established by the Alberto Jiménez Valderrábano Elementary School, which allows to strengthen the mathematics teaching-learning process in first grade children with hearing impairment and contribute to an equitable and inclusive education by reducing educational inequality in this exposed sector of the population.

The importance of the article is in the first place, the solution strategy that was proposed to support a vulnerable population, children with hearing impairment; according to the World Health Organization in 2020, more than 1,000 million people live on our planet with some type of disability, about 15% of the world's population; Of this population, almost 190 million have problems in their functioning and require assistance from third parties, another outstanding data is that of the Population and Housing Census 2020, which indicates that in our country Mexico has 6,179,890 people with some type of disability, representing 4. 9 % of the total population of the country. (National Institute of Statistics, Geography and Informatics [INEGI], 2020). Of these 22% are hearing impaired, despite the use of hearing aids, a situation that leaves them at a disadvantage in their social and educational environment mainly; secondly, applying an agile methodology called XP Extreme Programming for its simplicity and practicality to manage the project, allowed to obtain a quality software, completed on time and under the specifications of the educational institution linked.

Researchers' projects that serve as a reference for the proposed research were identified, and the following were found:

Researchers Fernandez and Fernandez et al. (2020) present a software solution with a user-centered design and usability techniques for hearing impaired people, basically children, to interact with the system and allow them to exercise communication activities.

Díaz Vásquez et al. (2021) propose a tactile technology to be used in the education of students with special impairments such as deafness in two educational institutions in Ecuador in order to improve teaching at school and at home.

The conference "Inclusive learning: school performance in arithmetic with the mobile application for the deaf" by Rodríguez Peña et al. (2019) propose a mobile application to improve school performance in mathematics, specifically in the area of arithmetic in deaf elementary school students.

Herrera Rivas (2022) in his Thesis "Aplicación del Modelo de Desarrollo Evolutivo en un Software Educativo" proposes visual didactic material that consolidates the teaching-learning process in mathematics for deaf students in basic education.

Del Pezo Izaguirre et al. (2021) identify various Teaching-Learning (TL) methodologies that when combined with mobile applications and Extended Reality (XR) technology have a positive impact on the academic performance of hearing impaired students.

Skultety et al. (2023) propose a framework that offers a way to develop a teaching practice to support mathematics teacher preparation within existing content and methods courses based on the current landscape of mathematics learning.

Alasim (2023) investigated Saudi Arabian primary school teachers' knowledge of strategies for teaching components of reading to students with hearing difficulties.

XP Extreme Programming

Extreme Programming, known as XP, is an agile methodology with the objective of responding quickly and with quality to customer requirements and achieving customer satisfaction. It considers that customer requirements change throughout the process and that it is necessary to adapt in an agile way. In Kent Beck's words, it is "a light, low-risk, flexible, predictable, scientific and fun process". It is based on four interdependent values: Simplicity, communication, feedback and courage.

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It proposes very short and fast process cycles, with immediate unit testing and continuous integration. The versions developed are functional, iterative and incremental until all customer requirements are met (Gómez Palomo and Moraleda Gil, 2020). Figure 1 shows the phases of XP, its iterative, simple and agile behavior, as well as the activities performed in each phase of the methodology.

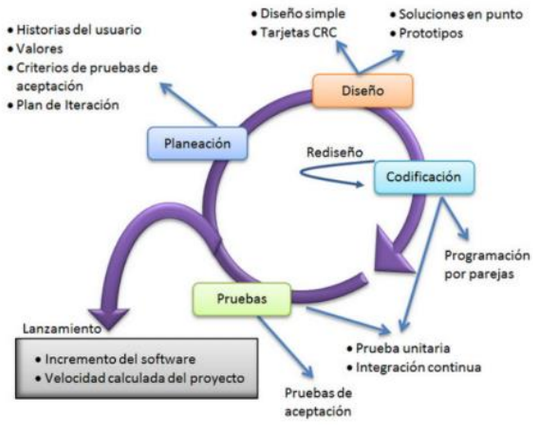

Figure 1 Extreme Programming according to Beck
Source: Gómez Palomo and Moraleda Gil (2020)

.NET Framework

It is a platform for the development of software of all types from desktop programs to web applications, it provides different services to developers' applications without being limited to a programming language or operating system. It consists of two components: the Common Language Runtime (CLR), considered as the execution engine, and the .NET Framework class library, which provides developers with reusable and tested code.

The services provided by the .NET Framework to running applications are as follows:

Memory management. The CLR component is in charge of obtaining the maximum usefulness of the memory.

Common type system. The type system defines the basic types common to the different language.

Extensive type library. An easily accessible type library is provided to programmers.

Development frameworks and technologies. It offers a diversity of libraries for application development areas.

Language interoperability. The language compilers that use .NET generate a Common Intermediate Language (CIL) that at the same time is compiled at runtime through the CLR, making routines written in one language accessible to other languages.

Version compatibility. All applications developed in previous versions can be executed without problems in later versions.

Parallel execution. The resolution of conflicts between versions is offered, and several versions of the CLR are installed on the computer without generating problems.

Multi-version support: Developers can create diverse class libraries that operate on .NET Framework platforms compatible with the .NET Standard version (Microsoft Learn, 2023).

Visual studio

It is an IDE for .NET developers on Windows that allows you to compile rich and attractive cross-platform applications for Windows, Mac, Linux, iOS and Android operating systems. It compiles applications with a wide variety of technologies.

Visual Studio's features allow you to increase productivity, improve code quality, and provide agility to the development team (Microsoft, 2023).

C#

It is a modern, object-based, type-safe programming language. C# allows developers to create many types of type-safe applications.

C# programs run on .NET, with the two components described: the CLR and the class library. The CLR runtime engine is Microsoft's implementation of the Common Language Infrastructure (CLI). CLI is the foundation for creating execution and development environments in which languages and libraries work seamlessly (Microsoft Learn, 2023).

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Mexican sign language

Mexican Sign Language is the language of the deaf community in Mexico, and is formed by a set of signs articulated with the hands and accompanied by facial expressions and body movements, the vocabulary of the language and its grammar are complex and vast.

There are variations in Mexican Sign Language according to the geographical location of the country, and it differs with languages by word order and in the use of verbs. (Government of Mexico, 2019).

The problems that the research aims to address are the difficulties encountered by teachers from the first grade of primary school in teaching mathematics to students with hearing disabilities, as well as the lack of interactive teaching materials implemented in public educational institutions that adhere to the educational programs of the Ministry of Public Education, in Mexican Sign Language. As a result, a desktop application will be obtained, for the Windows operating system, implemented under the XP methodology and the C# programming language in .NET Framework, easy to implement and maintain.

The article is organized as follows: first section is the introduction where the problem to be addressed and the proposed solution are described, as a second section you will find the software development methodology that was implemented for the development of educational software for teaching mathematics in first grade elementary school children with hearing impairment developed in .NET Framework. In the third section you will find the results where the images of the developed application are shown. In the fourth section you will find the acknowledgements and funding sources, the conclusions of the work done and finally the references.

Methodology

The software development methodology applied was XP Extreme Programming. Table 1 lists the activities performed in the phases of the methodology:

Activities of the Planning phase:	• Collection of User Stories • Define the Plan of Deliveries and Iterations • Weekly follow-up meetings
Activities of the Design phase:	• Simple design • CRC cards • Weekly meetings
Activities of the Coding phase:	• Pair programming • Sequential and continuous integration • Recode if necessary • Weekly meetings
Activities of the Testing phase:	• Unit Testing • Acceptance testing • Weekly meetings

Table 1 Planning of activities by phase
Source: Own elaboration

Planning and design

In order to specify the software requirements, the XP methodology proposes dynamic and flexible cards; the following is a simplified list of Educational Software User Stories and Figure 2 shows as an example the HU2 User Story, the card describes its behavior, users involved, estimation of its development, among others.

HU1: Organize the learning of hearing impaired children through sections called Blocks indicated in the book of Mathematics for the First Grade of Primary School provided by the Ministry of Public Education.

HU2: To contain in each block a set of visual and interactive activities that promote the learning of hearing impaired children.

HU3: Instruct each activity with images and short sentences in Spanish, reinforced with Mexican Sign Language.

HU4: Contain for each block a final evaluation of the hearing impaired child's learning.

HU5: Contain feedback in Mexican Sign Language in all activities.

USER HISTORY	
NUMBER: HU2	**USER:** Student with hearing impairment, teacher of the group
NAME OF STORY: Block Activities	
BUSINESS PRIORITY: High (High, Medium, Low)	**DEVELOPMENTAL RISK:** Medium (High, Medium, Low)
ESTIMATED POINTS: 4 weeks	**ITERATION ASSIGNED:** 2
RESPONSIBLE DEVELOPER: Carmen Jeannette Sampayo Rodríguez, Blanca Areli González Martínez	
DESCRIPTION: Contain in each block a set of visual and interactive activities that promote learning for hearing impaired children.	
REMARKS: Only defined users (hearing impaired students) will have access to the educational software functionalities.	

Figure 2 User History Card HU2
Source: Own elaboration

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Figure 3 presents the System Delivery Plan and Iterations, considering that four weeks of work were required for each iteration.

USER STORIES	ITERATION	PRIORITY	EFFORT	DATE START	DATE FINAL
HU1	1	High	2	05/12/2022	13/01/2023
HU2	2,3,4	High	2	16/01/2023	21/04/2023
HU3	2,3,4	High	2	16/01/2023	21/04/2023
HU4	2,3,4	Medium	2	16/01/2023	21/04/2023
HU5	2,3,4	Medium	2	16/01/2023	21/04/2023

Figure 3 Delivery Plan and Iterations
Source: Own elaboration

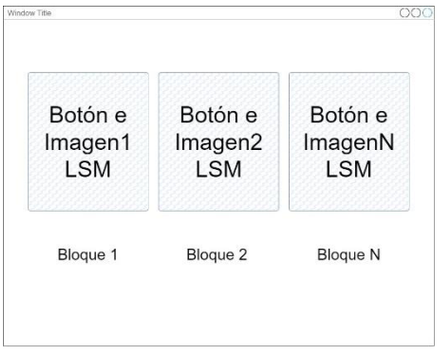
For the simple design of the application that would allow understanding the general structure of the Educational Software, the Draw.io tool was used, where each graphical user interface was created as it would be perceived by the hearing impaired children, considering at all times a simple and intuitive structure.

The free primary level textbooks are inclusive by considering gender equality and interculturality, however, they were not designed for children with hearing or visual disabilities.

Achieving an intelligible design is to facilitate, complement and strengthen the learning of the hearing impaired child by being fed back with images and Mexican Sign Language at all times.

Figure 4 (a) shows the Home view combining Spanish statements with Mexican Sign Language and (b) visualizes the three Blocks in which the content of the Educational Software is organized, as indicated by the Ministry of Education in the book Mathematics, First Grade.

a)



b)

Figure 4 a) Startup Interface Design b) Draw.io Educational Software Blocks Menu Interface Design
Source: Own elaboration

Figure 5 shows the organization of the interface of the Block's learning activities, with statements in Spanish and action buttons reinforced with images alluding to the topic.

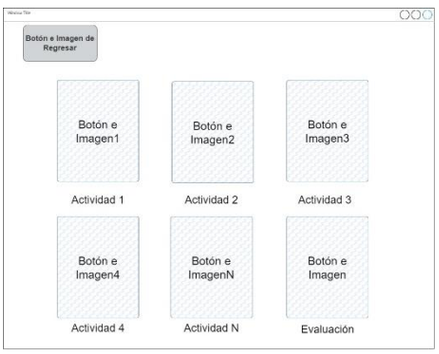


Figure 5 Interface Design of Activities per Block in draw.io
Source: Own elaboration

Figure 6 (a) shows the design of the interface when the child with a disability chooses an activity, instructions in Spanish with their respective translation into Mexican Sign Language, the execution of the exercise, and (b) shows the feedback on the performance of the exercise.

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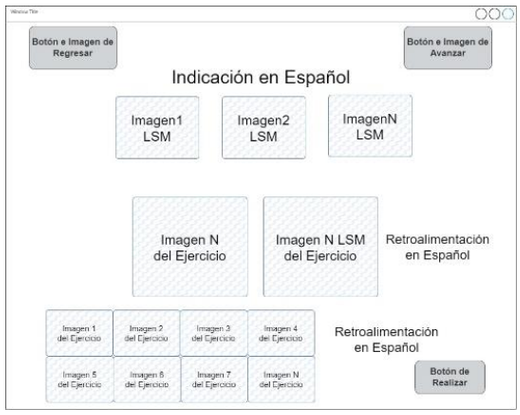
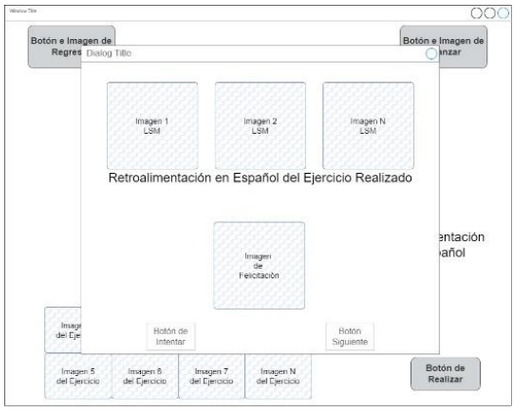


a)



b)

Figure 6 a) Interface Design of the Activity. b) Interface Design with feedback of results in draw.io
Source: Own elaboration

Software architecture is a description of the subsystems and relationships that make up a system. The architecture used was monolithic, distinguished by the fact that it is easy for the development team to initiate the project and get it up and running, also because it is a stand-alone application, which allows it to operate independently of other applications, and the processing is done locally because it does not require consuming distributed processes to complete a task. A typical monolithic application uses an independent layered design for the user interface, application logic and data access (Blancarte Iturralde, 2023).

Figure 7 presents the monolithic software architecture represented in a deployment diagram, with a layered design used for the implementation of the Educational Software.

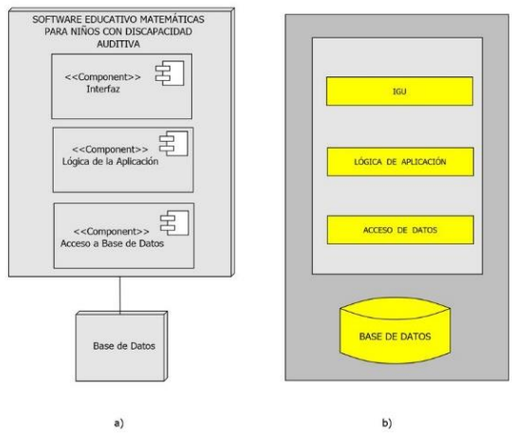


Figure 7 a) System Deployment Diagram b) System Layer Design in Dia
Source: Own elaboration

CRC cards facilitate the identification of classes that will intervene in the application. Designing these cards is appropriate to improve the understanding of the design. For the project, 4 CRC cards were designed with the Classes: Block, Activity, Evaluation and Student with Hearing Impairment as shown in Figure 8.

BLOCK	
Responsibility	**Collaboration**
Save Block information	
Verify Activities	Activity
Verify Evaluations	Evaluation

ACTIVITY	
Responsibility	**Collaboration**
Saving activity information	
Verify activity information	
List activities	
Verify the blocks	Block

EVALUATION	
Responsibility	**Collaboration**
Saving evaluation information	
Verify activity information	Activity
Verify evaluation information	
Report evaluation performance	Student with HI

STUDENT WITH HI	
Responsibility	**Collaboration**
Save HI Student Information	
Verify HI Student Information	
Verify activity information	Activity
Verify performance information from evaluations	Evaluation

Figure 8 System CRC cards
Source: Own elaboration

Coding and Testing

Organizing the solution as a project, in order to have a well-defined structure is important for educational software. A good practice is to structure in a tree structure through directories or folders, which in turn will contain files for easy access and categorized storage.

Visual Studio, when starting a project, contains all the files that are compiled into an executable file. These files may include source code, icons, images, data files, etc. It also contains compiler configuration and other configuration files that might be needed (Microsoft, 2023).

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Figure 9 shows the graphical representation of the Educational Software file and folder hierarchy, in which the Visual Studio Solution Explorer nests related files to help programmers organize them and make them easier to locate.

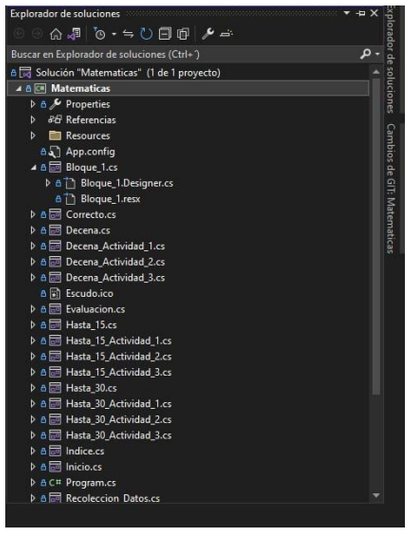

Figure 9 Organization of folders and files of the Educational Software
Source: Own elaboration

Figure 10 shows the coding that was developed for the Block 1 activity set form.

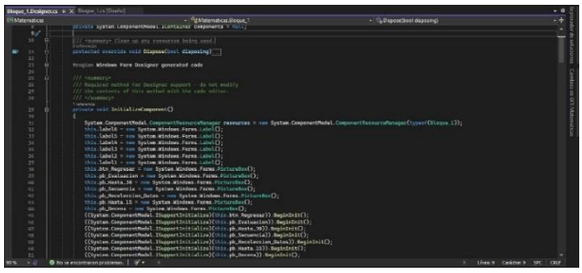

Figura 10 Code of the form Index of Activities of Block 1
Source: Own elaboration

For the Testing phase, Unit and Acceptance Test Cases were designed to verify the correct functioning of the educational software and guarantee a quality product.

Figure 11 shows the template used for the User Story Test Case CP_HU4 Final evaluation of Block 1.

TEST CASE	
CODE: CP_HU4	**USER HISTORY NUMBER**: HU4
USER STORY:	
Final evaluation of Block No. 1	
CONDITIONS OF EXECUTION:	
The USER (hearing impaired student) is required to be logged in and to have completed all the activities in block No. 1 to be evaluated	
INPUT/EXECUTION STEPS:	
The USER (hearing impaired student) will have to enter the block he/she wants to make his/her evaluation, for the case No. 1. The USER (hearing impaired student) will have to select the Evaluation image. The USER (hearing impaired student) will have to perform the final activities. The SYSTEM will indicate the status of the evaluation with a brief statement and Mexican Sign Language. The USER (hearing impaired student) will be able to repeat the evaluation if desired.	
EXPECTED RESULT:	
Evaluation of Block 1 completed and saved.	
EVALUATION OF THE TEST:	
The functional type test is: Satisfactory / Partially Satisfactory / Not Satisfactory.	

Figure 11 Test Case CP_HU4, designed for execution in Iteration 2
Source: Own elaboration

This is how to achieve a project that will allow you to follow up and maintain it in the best way and achieve a much simpler implementation of new functionalities.

Results

The following are the interfaces of the Educational Software for teaching mathematics to hearing impaired children in the first grade of primary school developed in .NET with the IDE Visual Studio under the C# programming language.

Figure 12 shows the Home view of the Educational Software and the following one shows the three blocks in which the learning of the subject Mathematics for children in first grade of primary school is organized according to the free educational book authorized by the Ministry of Public Education (Secretaría de Educación Pública, 2019).

Figure 12 Startup Views and Block Organization of the Educational Software
Source: Own elaboration

Figure 13 shows the view with the index of the set of learning activities that the hearing impaired child could choose, in this case, the activities of Block 1 and their corresponding evaluation are exemplified. Images taken from the First Grade Mathematics book authorized by the Ministry of Public Education and the signs from the book Manos con Voz (Serafín de Fleischmann and González Pérez, 2011) were included.

Figure 13 View of the Index of Activities of Block 1.
Source: Own elaboration

In Figure 14, if the activity "Up to 15" is chosen, the exercise that the child with a disability must solve is presented. All the activities have a brief instruction in Spanish that is reinforced with Mexican Sign Language, and at the end the exercise is fed back in the same way.

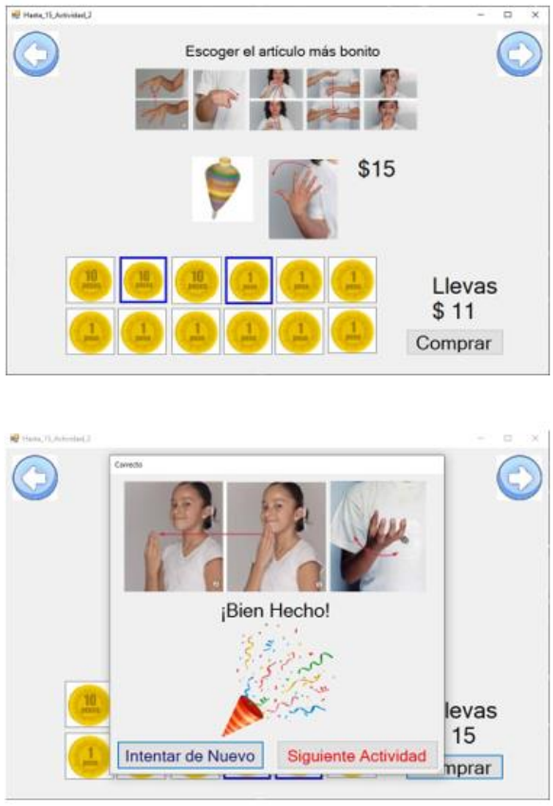

Figure 14 Views of the Activity "Up to 15" of the Educational Software
Source: Own elaboration

Acknowledgments

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Conclusions

In conclusion, it was possible to implement a sustainable and local educational software for the Windows operating system following the agile methodology XP Extreme Programming, the C# programming language, the Visual Studio IDE in .NET Framework, resulting in a friendly desktop application and easy maintenance to promote new features in the future.

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One of the future improvements is that this application works on mobile devices so that it can be consulted by its users at any time and place desired.

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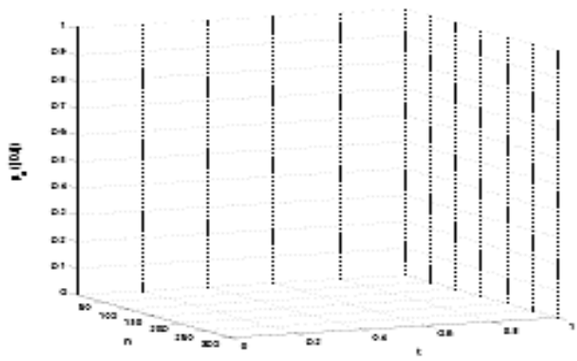

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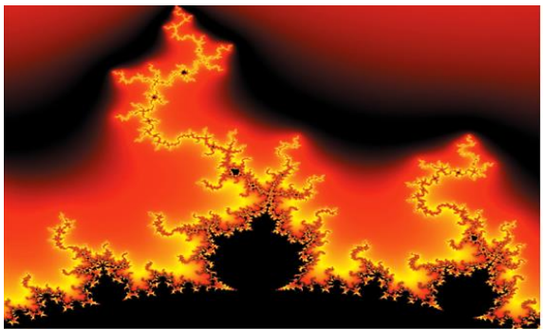

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