Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

https://doi.org/10.23913/ride.v13i25.1235

Artículos científicos

Aplicación móvil como apoyo en la práctica de la destreza operatoria aritmética de estudiantes de secundaria

Mobile Application to Support the Practice of Arithmetic Operative Skills with High School Students

Aplicativo móvel como suporte na prática da habilidade operatória aritmética de estudantes do ensino médio

Elena Fabiola Ruiz Ledesma
Instituto Politécnico Nacional, Escuela Superior de Cómputo, México
eruizl@ipn.mx
https://orcid.org/0000-0002-1513-8243

Lorena Chavarría Báez
Instituto Politécnico Nacional, Escuela Superior de Cómputo, México
lchavarria@ipn.mx
https://orcid.org/0000-0002-8746-6342

Karina Viveros Veña
Instituto Politécnico Nacional, Escuela Superior de Cómputo, México
kviveros@ipn.mx
https://orcid.org/0000-0003-1499-2250

Resumen

En el presente artículo se propone una aplicación gamificada móvil que promueva la resolución de ejercicios aritméticos empleando solo el conjunto de los números naturales. Para el desarrollo de la investigación, se empleó una metodología descriptiva mixta. Y para validar la aplicación, se realizaron pruebas de funcionamiento y de usabilidad. Estas últimas con una muestra aleatoria de 50 estudiantes que cursaban los tres años de la educación básica (secundaria), a quienes se les explicó vía remota el uso de la aplicación, y durante una semana la emplearon para practicar su destreza operatoria. Los estudiantes respondieron el cuestionario "Escala de usabilidad de sistemas" (SUS), también vía remota. Entre los resultados destaca que la aplicación tuvo un buen nivel de aceptación, de acuerdo con la escala de evaluación propuesta por la literatura (68-80.3). Además, al revisar la satisfacción del usuario, la eficiencia, efectividad, tasa de errores y memorabilidad, se encontró que los estudiantes de la muestra consideraron a la aplicación con una alta eficiencia: no encontraron errores al usar la aplicación, les resultó muy intuitiva y comentaron que ir desbloqueando los niveles contribuyó a que estuvieran motivados y concentrados, debido a que buscan estar en los primeros niveles de la tabla de liderato. Se concluye que las mecánicas y dinámicas empleadas de la gamificación permitieron al estudiante practicar su destreza operatoria.

Palabras clave: aplicación móvil, Aritmética, destreza operatoria, gamificación, educación secundaria.

Abstract

In this article, a mobile gamified application is proposed that promotes the resolution of arithmetic exercises using only the set of natural numbers. For the development of the research, a mixed descriptive methodology was used. A random sample of 50 students who were in the last three years of basic (secondary) education was considered. To validate the application, performance and usability tests were carried out, the latter with a sample of the target population (high school students), to whom the use of the application was explained remotely, and for a week they used it to practice their operative dexterity. The students answered the System Usability Scale (SUS), also remotely. Among the results, it stands out that the application had a good level of acceptance, according to the evaluation scale proposed by the literature (68-80.3). In addition, when reviewing user satisfaction, efficiency, effectiveness, error rate and memorability, it was found that the students in the sample considered the application to be highly efficient: they did not encounter errors when using the application, they found it very intuitive and they commented that unlocking the levels helped them to be motivated and focused, because they seek to be in the first levels of the leadership table. It is concluded that the mechanics and dynamics used in gamification allowed the student to practice their operative skills.

Keywords: mobile application, arithmetic, operative dexterity, gamification, secondary education.

Resumo

Neste artigo, é proposto um aplicativo gamificado para celular que promove a resolução de exercícios aritméticos utilizando apenas o conjunto dos números naturais. Para o desenvolvimento da pesquisa, foi utilizada uma metodologia descritiva mista. E para validar a aplicação, foram realizados testes de performance e usabilidade. Este último com uma amostra aleatória de 50 alunos que se encontravam nos três anos do ensino básico (secundário), a quem foi explicado o uso da aplicação remotamente, e durante uma semana utilizaram-no para praticarem as suas competências operacionais. Os alunos responderam ao questionário "Escala de Usabilidade de Sistemas" (SUS), também remotamente. Dentre os resultados, destaca-se que o aplicativo teve um bom nível de aceitação, de acordo com a escala de avaliação proposta pela literatura (68-80,3). Além disso, ao analisar a satisfação do usuário, eficiência, eficácia, taxa de erro e memorização, verificou-se que os alunos da amostra consideraram o aplicativo altamente eficiente: não encontraram erros ao usar o aplicativo, acharam-no muito intuitivo e Eles comentaram que desbloquear os níveis os ajudou a ficar motivados e focados, pois buscam estar nos primeiros níveis da tabela de liderança. Conclui-se que as mecânicas e dinâmicas utilizadas na gamificação permitiram ao aluno praticar suas habilidades operacionais.

Palavras-chave: aplicativo móvel, Aritmética, destreza operativa, gamificação, ensino médio.

Fecha Recepción: Enero 2022 **Fecha Aceptación:** Julio 2022

Introduction

Arithmetic and geometry are among the oldest and most necessary mathematical disciplines for mankind (Coronado, 2014). Its functional use is required for the people who participate in this society as a means of communication and understanding of a multitude of phenomena that surround us. That is why the development of arithmetic operative skill is one of the skills most needed in socio-instrumental literacy (Coronado, 2017).

The results obtained in the area of mathematics in international assessments such as the Program for International Student Assessment (PISA) of the Organization for Economic Cooperation and Development [OECD] (2016, 2018) are below average, and much of that failure has its origin in arithmetic calculation, since this is fundamental in the process of solving problems. In short, it is one of the key contents of mathematics (Mullis, Martin, Foy and Hooper, 2016). Orrantia (2006, 2017) points out that many of the difficulties that occur in learning mathematics fall on arithmetic aspects.

The results of the National Plan for the Evaluation of Learning (Planea) (National Institute for the Evaluation of Education [INEE], 2018) for the sixth grade of primary school are disappointing. The INEE applies the Plana test to a sample of students that allows drawing a panorama at the national, regional, federal entity and type of school level (general public, indigenous, community and private). For 2018, the sample consisted of 104,973, corresponding to 3,573 schools. In mathematics, the exam consisted of 147 items corresponding to the axes of "Number sense and algebraic thinking", "Form, space and measurement" and "Information processing". The score obtained by the student would place him/her in one of the following scales: 1) insufficient mastery, 2) basic mastery, 3) satisfactory mastery and 4) outstanding mastery. Of the total sample, 59% were found at the level of insufficient domain. It should be noted that this test covers the topics of basic operations with natural numbers, calculating perimeters of regular figures, and interpreting bar graphs.

For Carpenter and Mosser (2022), the operative arithmetic skills of middle and high school students are in decline. The student trusts that he will be able to have the calculator on his cell phone at all times, but, when this is not possible, as in the admission exams, the lack of mental calculation training hinders the correct solution of the reagents of said exams. On the other hand, not strengthening the operative dexterity affects different cognitive processes when reaching adulthood (Martin et al., 2003). Presenting the exercises to the student in a routine way often causes boredom and demotivation (Zepeda, Abascal and López, 2016). The motivation and emotional state of students is also fundamental, since they represent a key factor in their academic performance (Larrazolo, Backhoff and Tirado, 2013). If we want young Mexicans to have a better performance in the area of mathematics, it is necessary to introduce them to different ways of learning and practicing their knowledge. For this, a support strategy is gamification (Hsin-Yuan and Soman, 2013), which is used to encourage secondary school students to develop their operating skills through the use of technology.

The problem addressed in this article is the need to strengthen the arithmetic operative skills of high school students through the use of a mobile application that incorporates gamification techniques, which is important for the development of students' mathematical thinking. This article describes how this application was built.

The question that guided this research was: how to develop a mobile application that allows high school students to practice operations with natural numbers, and to feel motivated and committed to this practice?

The document was organized as follows: in the state of the art, studies are commented on the relevance of practicing arithmetic operative skill, mobile applications used in academic work, particularly in the area of mathematics, and aspects of gamification; the third section deals with the method and materials used in the investigation; in the fourth section the quantitative results and their qualitative analysis are presented, and in the fifth section the conclusions are shown.

Below are some studies related to the objective of the research that have been classified into three categories. The former refer to the importance of developing arithmetic operative skills and the strategies used by students in solving exercises with basic operations. The second part shows studies that address the importance of mathematical work with the use of mobile applications. And the third part refers to the importance that gamification has reached in academic work, its elements and mechanics, which many mobile applications already include. Some aspects of both arithmetic and mobile applications and gamification are used in the application that was developed and is described in this article.

State of the art

Regarding the acquisition and development of basic arithmetic content, some arise from informal experience, such as some aspects of number development, considering two key elements: counting and protoquantitative schemes (Resnick, 1989, 2020), which do not require of an explicit teaching; while others are acquired through teaching.

In relation to counting, from the cognitive point of view, although it is considered as a simple activity for the adult, it really is a long process for the child, which possibly culminates until the age of seven or eight, and which requires the use of principles and strategies (Geary, Brown and Samaranayake, 1991).

The principles referring to the conceptual knowledge of counting are: biunivocal correspondence (one to one), stable order, cardinality, abstraction and irrelevance, which were developed by Gelman and Gallistel (1978) and worked on in their research, first by LeFevre et al. (2006), and later in time by McGuire, Kienkie, and Berch (2012).

Parallel to the ability to count, children develop some experience in the field of numerical relationships, which are defined by Resnick (1989, 2020) as protoquantitative schemes and refer to expressions referring to quantities, but without numerical precision, which allow size comparisons to be made by assigning linguistic labels such as, greater, less, more, less.

Some of the strategies that the child uses and that they discover intuitively or empirically are: direct modeling, which consists of using physical objects, fingers or drawing elements to represent the situation to be solved (Geary, Hoard and Nugent, 2012) ; counting from the largest, which consists in that, given an addition situation, the child starts from the largest number and adds the smallest to it (Siegler and Jenkins, 2014). It is important to keep in mind that to use this strategy it is necessary to have several requirements; the first is to be able to start counting from any arbitrary point in the number series. Other requirements have to do with the meaning of the relationships between count and cardinality.

As far as the subtraction operation is concerned, there are two strategies that are widely used by children, one has been called count-back and the other count-up (Fuson, Carroll, & Landis, 1996). Back-counting consists of counting in the opposite way to the usual count, that is, in reverse. Counting up consists of starting from the smallest set of elements and counting until you reach the value of the largest set.

Among other strategies used to perform arithmetic operations is what is called retrieval of facts or direct solutions, which consists of remembering the result of simple operations. Another strategy is called derived facts or indirect solutions (Fuson et al., 1996), which consists in that, given two quantities that must be added or subtracted, one of them is decomposed in two and they are grouped, that is, the numbers of an operation are organized in such a way that well-known additions or subtractions are presented. A particular case of the derivative facts strategy consists of using the redistribution based on 10, which is widely used in combinations in which one of the addends is nine.

This strategy of derived facts can also be used with combinations of numbers in multiplication and division. Examples are the rule of zero and the rule of multiplying by one (Orrantia, 2017).

These rules and procedures represent a path that allows numerical facts to be retrieved from memory and practice in this field allows the use of said rules in a more automatic way. (Orrantia, 2017).

In primary school, many teachers perform mental math exercises to help children transition from counting to retrieving arithmetic facts. That is why this article works on this practice through the use of some aspects of gamification. In particular, the application uses the operations of addition, subtraction, multiplication and division with the set of natural numbers.

Once an analysis of the cognitive process that occurs in children on the basic operations in the field of arithmetic has been carried out, some of the difficulties that can occur during the process in question will be mentioned immediately. A first difficulty that arises is the disconnection between the formal arithmetic that is taught in school and the informal one that children develop empirically.

Sometimes, children are unable to connect rules that they memorize at school with the informal arithmetic developed (Fyfe, McNeil, & Borjas, 2015), so they consider that the knowledge of mathematics that they learn in the classroom is not useful for solving problems. of real life. Situation that represents one of the factors that trigger various difficulties that some students present in approaching mathematics.

In general, the difficulties in the treatment of arithmetic can be classified into two: one type of difficulty corresponds to those that appear in the domain of numerical combinations and the other type has to do with problem solving, although the The former influence the latter. (Alibali, Phillips y Fischer, 2009).

The difficulties associated with the arithmetic calculation are presented both in the procedural part and in the retrieval of facts through memory. As far as the procedural ones are concerned, they are related to an immature knowledge of counting. On the other hand, the difficulties that refer to the recovery of facts are related to errors that occur during the execution of some calculation strategy seen in previous paragraphs.

Given the difficulties indicated, the purpose pursued with the application that was developed is precisely that the student can practice using the strategies for both retrieval of facts and derived facts, the rules of multiplying by zero and by one, for which makes use of game dynamics.

A review of studies was made that refer to the importance that mobile applications have come to have in the teaching-learning process, specifically in arithmetic. And in this line, Moral, Sánchez and Sánchez (2021) developed a study with 200 students of primary education level in order to determine if the use of mobile applications with digital materials in the subject of Arithmetic replaces the role that the materials had. physical manipulatives and the impact on motivation and the degree of learning in students with these materials. The results obtained show that they are not only valid for practicing the contents dealt with, but also that the use of active methodologies in which these digital tools are embedded increases motivation and the degree of satisfaction with the teaching-learning process of the subject.

The success in learning outcomes after the use of educational applications is due to various factors. In the case focused on the learning of mathematics, Gersten and Chard (2009) comment that the usefulness comes from the fact that they include numerous repetitions, accumulation of mathematical concepts, early challenges and rewards, in addition to the fact that students set their own pace. of learning, because, in most cases, the activities are level. According to research by Segal (2011), children obtain better performance in mathematics when they use tablets through direct touch on the screen, since physical manipulation of objects occurs, which benefits cognition and learning, compared to indirect touch devices such as the computer mouse.

Gunnar and Folkesson's (2012) research, meanwhile, concludes that the direct manipulation of virtual objects, verbal labels and numerical representations produces active learning in the student because the simultaneous presentation of auditory and visual inputs generates learning. multisensory, a situation that facilitates understanding (Outhwaite, Faulder, Gulliford, & Pitchford, 2019).

Regarding the content of the applications and the student's connection with them, authors such as Barab, Gresalfi and Ingram-Goble (2010) and Sommerfeld (2009) indicate that applications that position the user as a problem solver make disciplinary knowledge a tool that is used to solve these problems and in this way higher rates of learning and motivation are achieved. Frequently, when new content is presented to students, it is done in a disconnected and external way to them, who position themselves as mere spectators whose role is to remember static knowledge. Furthermore, in this context, the responsibility for acquiring that knowledge is external (Gresalfi, Martin, Hand, & Greeno, 2008). On the contrary, the applications can provide a framework that legitimizes the participation of the students, since they create the need to master the content if one wants to solve a problematic situation, and the need to apply disciplinary knowledge. These contexts provide users with the opportunity to determine when to use certain content. (Barab *et al*., 2010).

It was considered to work with some aspects of gamification because the student shows a good level of commitment when motivated (Fernández, Olmos and Alegre, 2016).

In the NMC Horizon Report (Johnson, 2020) it is pointed out that game-based learning and gamification as a teaching strategy, including game dynamics and elements in the field of education, allows increasing student motivation and that this trend is increasing. valid.

Now, gamification is commonly defined as:

> The use of techniques, elements and dynamics typical of games in contexts that are not games, in order to enhance motivation, as well as reinforce behavior to solve a problem, improve productivity, achieve a goal, activate learning (Robson, 2015, p. 412).

In that line, a game is:

> A formal rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player strives to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable *(*Zichermann y Cunningham, 2011, p. 12).

In addition, the three elements involved in gamification, according to Hunter and Werbach (2012), are the following: dynamics, mechanics, and components. The dynamics are the global aspects related to the motivational effects and desires that are intended to be generated in the participant. Some dynamics are: the narrative, game restrictions, the possibility of solving a problem in a limited environment, emotions such as curiosity or competitiveness. The mechanics are the rules that generate a certain commitment for the users; they highlight challenges, competition, collaboration. The components are concrete elements or specific instances, they can vary in type and quantity, everything depends on the creativity in which the game is developed; some are: avatars, badges, achievements.

Gamification uses different types of rewards to encourage desired behaviors (Prasad and Rao, 2020). These rewards are generally conceptualized with the acronym SAPS, made up of the initials of the following terms (in its English version):

- *Status,* recognition. Leaderboards are an example.
- *Access,* they offer the possibility of accessing a point or something that other individuals cannot.
- *Power,* for example, in forums where those with the most points do not have to go through review.
- *Things (stuff),* tangible rewards.

The gamification elements that were used in the construction of the mobile application presented in this article are:

- Leader boards.
- Punctuation system.
- Achievements.

These elements are some of the most common and have been shown to impact student motivation in the studies reviewed. (Wiggins, 2016)

Methods and materials

The developed study is of a qualitative-descriptive nature, according to what was pointed out by Hernández, Fernández and Baptista (2008), because the questionnaire and the interview were used as methodological instruments to describe the usefulness of the application. The interview allowed to deepen in some answers given by the students. For the collection of the information given by the questionnaires, basic statistics were used, which allowed describing the aspects of satisfaction with the use of the application, as well as its ease of use by a sample of 30 first-year students of the level high school, who worked with the application for two weeks remotely and there was a first session through the Zoom platform, where they were explained how to navigate the application. This sample corresponds to a group already defined from a secondary school in Mexico City. The "Systems Usability Scale" (SUS) questionnaire was used to validate the application and place it at a level according to the experience presented by the user. The questionnaire used and its description is located in the last phase, called Testing and which corresponds to the phases of the software life cycle (Sánchez, Sicilia and Rodríguez, 2012). The first phases are: Analysis, Design and Implementation. The following describes what was done in each of them.

Phase 1: Analysis of the application

This section presents the first stage, which corresponds to the analysis and includes the collection of requirements and the use cases of the application.

Based on what was presented in the introduction of this article on arithmetic and gamification, the requirements of the application were established. The counting strategies used by a student were considered, as well as the commutative and associative properties of addition and multiplication of natural numbers. The distributive property that is used in combined operations of addition and multiplication was also considered.

In relation to the elements of gamification described in the first section of this article, of the dynamics, time was considered as one of the restrictions. Competition was used as mechanics, and achievements and leaderboards were included as components. In summary, the characteristics that were contemplated for the application are the following:

- Punctuation system.
- Arithmetic exercises.
    - Addition.
    - Subtraction.
    - Multiplication.
    - Division.
- Expression evaluator.
- Difficulty levels.
- Leader boards.
- Player statistics.

For the difficulty levels, the number of digits that appear in the operations was taken into account. It was decided that two digits would be included for an easy level, three digits for a medium level and four digits for an advanced level, this for the operations of addition and subtraction. For multiplication and division one digit was reduced.

This was based on what was established in the Key Learning plan for comprehensive primary education of the Ministry of Public Education [SEP] (2018), since the basic operations are gradually being introduced, taking into account the number of digits that have the figures to operate.

To develop this application, there is a User entity, with email (primary key) and password fields, with email as the entity's identifier, since duplicate emails are not allowed. Achievements and leaderboards are managed by the external Google Play Games service, so they are not included in our database.

Achievements are a way to encourage the player to meet certain goals. Here it was decided to focus on few achievements, but with three levels of difficulty: easy, medium and hard. Achievements are automatically unlocked by reaching a certain score, hitting a streak, or responding quickly. There are three categories of achievements: Streaks, Time, Score. The score is calculated based on the difficulty and response time as follows: score = $(a/b) * c$, where a is the response time, b is the time given to respond and c is the maximum score per response correct. Completing all achievements will not reset your progress.

Table 1 shows the names that were assigned to the achievements and what each one implies.

Tabla 1. Logros

Logro	Descripción
Inspirado	Consigue una racha de al menos cinco en el modo infinito.
Ascendido	Consigue una racha de al menos 10 respuestas correctas en el modo infinito.
Perfeccionista	Responde correctamente todas las preguntas en una ronda del modo Clásico.
Ágil	En el modo Clásico, termina una partida en menos de tres minutos con al menos siete respuestas correctas.
Veloz	En el modo Clásico, termina una partida en menos de dos minutos con al menos siete respuestas correctas.
Sub60s	En el modo Clásico, termina una partida en menos de un minuto con al menos siete respuestas correctas.
Académico	Consigue una puntuación de al menos 2500 en el modo Clásico, dificultad fácil.
Estudioso	Consigue una puntuación de al menos 500 en el modo Clásico, dificultad media.
Erudito	Consigue una puntuación de al menos 10 000 en el modo Clásico, dificultad difícil.

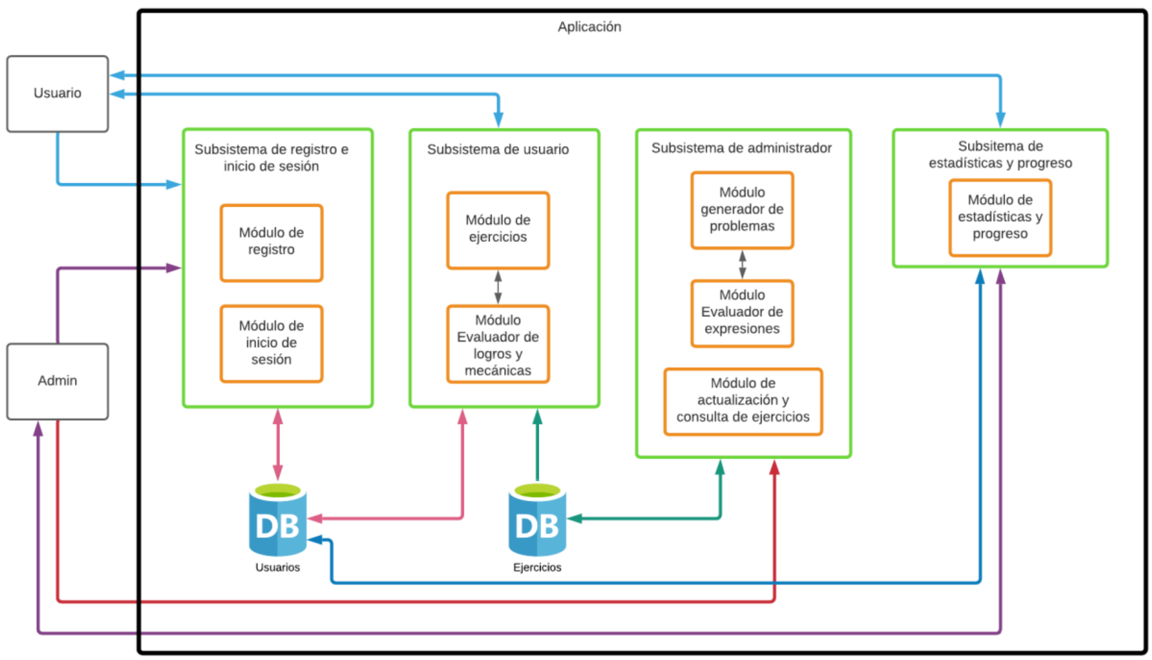
Fuente: Elaboración propia

Phase 2: Design of the application

The architecture is made up of four subsystems (see figure 1). The first subsystem is the Registration and Login subsystem and is responsible for registering and allowing access to already registered users. The second subsystem corresponds to the modules that interact with the user, these are the Exercises module, in charge of providing exercises to the user, and the Achievement and Mechanics Evaluator module, which is in charge of keeping track of the score, achievements and levels. The Administrator subsystem includes the Problem Generator and Expression Evaluator modules, which are used to generate the exercises for the user. An Update and Consultation module for these exercises is also included. The last subsystem is the Statistics and Progress subsystem, which keeps track of the user's global achievements.

Figure 1 shows the architecture of the application.

Figura 1. Arquitectura con los módulos de la aplicación.

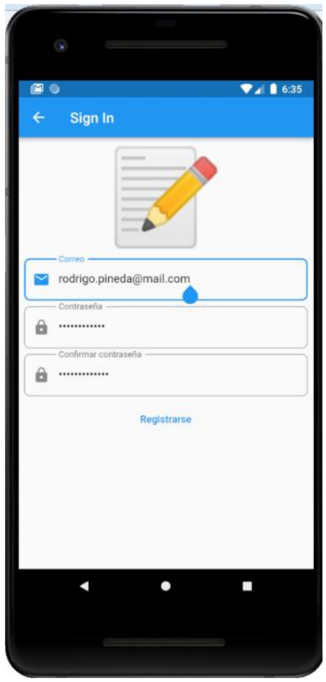


Fuente: Elaboración propia

Phase 3: Implementation of the application

In this phase the application was programmed. The registration and entry subsystem was programmed with the Dart language, and a framework called Flutter was used to present it in a mobile application (Rodríguez, and Arteaga, 2021). Figure 2 shows the registration screen, in which the email, password and password confirmation are requested. Login via email and password.

Figura 2. Pantalla de registro



Fuente: Elaboración propia

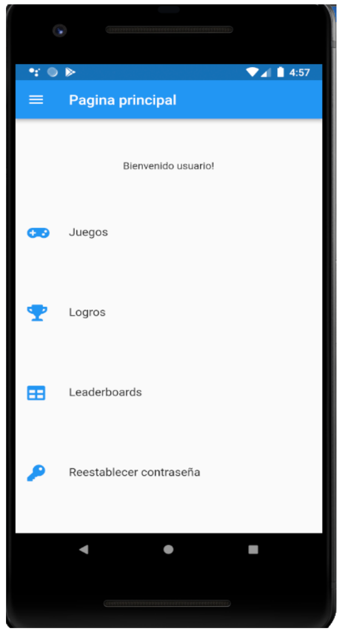
Figure 3 shows the login screen.

Figura 3. Pantalla de inicio de sesión

Fuente: Elaboración propia

Figure 4 shows the user's main screen.

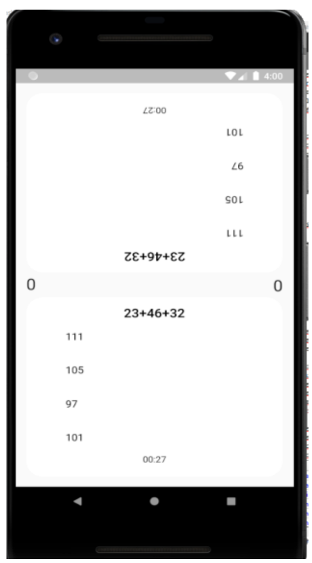
Figura 4. Pantalla principal



Fuente: Elaboración propia

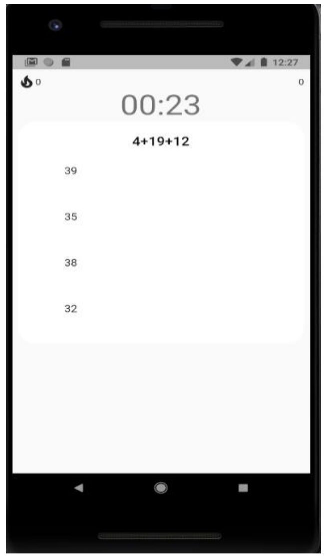
Figure 5 shows an example of Player versus Player game mode, the mode is designed for two users to play on the same device. Figure 6 shows the infinite mode of the game.

Figura 5. Jugador versus Jugador



Fuente: Elaboración propia

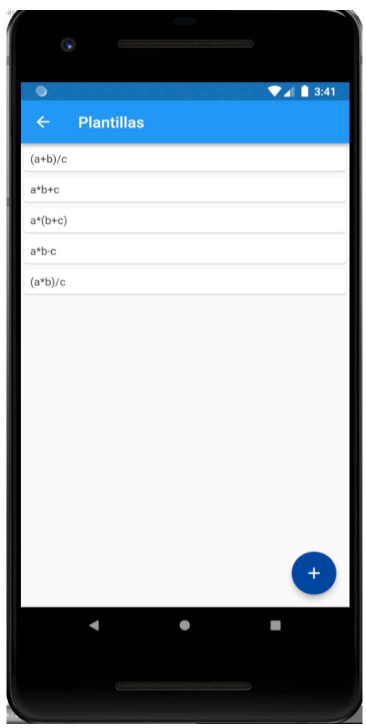
Figura 6. Juego en modo infinito



Fuente: Elaboración propia

Figure 7 shows the Templates screen and there is a list of them that are in the database. These templates are entered in the Template Creation screen, shown in figure 8, where the administrator must enter the necessary fields to create the template.

Figura 7. Plantillas



Fuente: Elaboración propia

Figura 8. Creación de plantilla

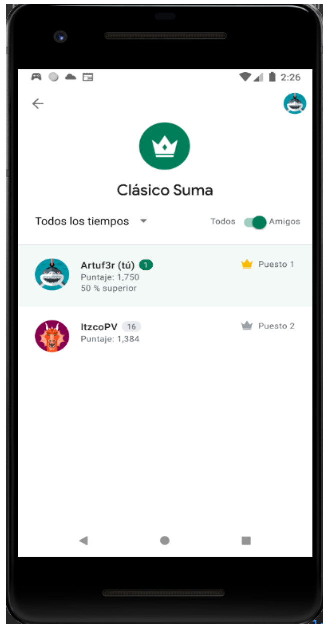
Fuente: Elaboración propia

Figure 9 shows the achievements screen in which the user will be able to know what achievements he has obtained. Figure 10 shows the screen where the leaderboard appears, through which the user can know where he is with respect to other users.

Figura 9. Logros obtenidos

Fuente: Elaboración propia

Figura 10. Lugar que ocupa



Fuente: Elaboración propia

Phase 4: Application testing

This section reports the tests performed on the application.

The first tests were those corresponding to the functionality of the system and a second type of tests were carried out with the aim of having a better vision about the user experience and the usability of the application.

Functionality tests

The mail was validated with a regular expression. Some examples of valid emails:

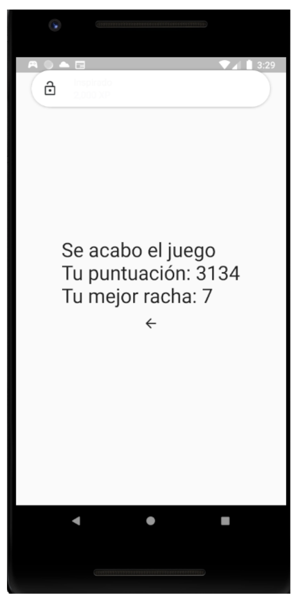
- itz80@kla.co
- itz!&*%^7@protonmail.net
- 1A!e@protonmail.com

The ability to unlock achievements was validated, as can be seen in the figures 11, 12 y 13.

Figura 11: Logros sin desbloquear

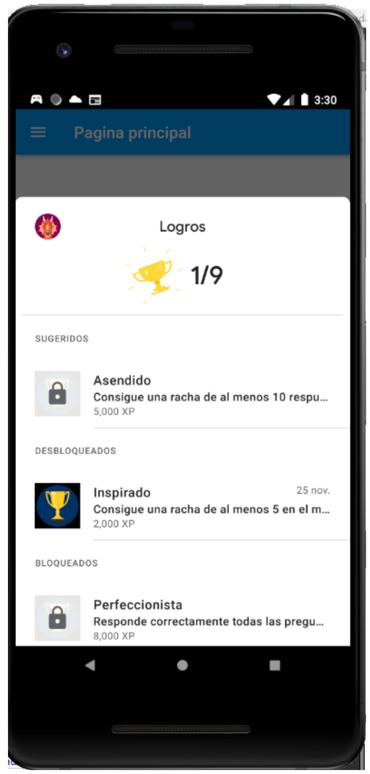
Fuente: Elaboración propia

Figura 12. Se cumplió la condición



Fuente: Elaboración propia

Figura 13. Logros desbloqueados



Fuente: Elaboración propia

User experience usability testing

User experience (expressed as UX) describes the subjective feelings of users towards the products they use. Different users may have different impressions regarding the UX of the same product. Therefore, it is necessary to measure the UX of a group to have greater confidence in the results (Santoso, Schrepp, Kartono, Utomo and Priyogi, 2020).

To carry out these measurements, Lewis and Sauro (2019) mention that the SUS questionnaire has become a valuable tool, since it allows evaluating usability and user experience. For his part, Sauro (February 3, 2011) showed that SUS is a valid and reliable usability questionnaire.

The SUS is a standardized questionnaire of ten questions with five options to answer, the response measurement range goes from totally disagree to totally agree and the values go from one to five, respectively. The values obtained are homogenized using the following formulas:

$$V_i - 1, \text{ if the reactant is odd} \quad (1)$$

$$5 - V_i, \text{ if the reactant is even} \quad (2)$$

There V_i represents the initially obtained value, indexed by i.

The evaluation of the questionnaire allows to classify the usability of the educational technological tool using the following operations: the transformed values of the answers obtained are firstly added and then multiplied by the factor 2.5. The results obtained that are greater than 68, but less than 80.3, are considered above average or are qualified with the adjective Good, which implies that the evaluated tool meets the required quality attributes. If a score greater than 80.3 is obtained, it is considered Excellent (Derisma, 2020). See table 2.

Tabla 2. Rango de evaluación del cuestionario SUS

Evaluación SUS rango	Evaluación SUS en adjetivo
> 80.3	Excelente
68-80.3	Bueno
68	Suficiente
51-68	Pobre
< 51	Muy deficiente

Fuente: Elaboración propia

The SUS questionnaire measures usability attributes, and according to Nielsen and Mack (1994), usability is defined by five quality components:

- *Learning.* It refers to how easy it is for users to perform basic tasks from the first time they work with the system.
- *Efficiency.* It consists of what users have learned to use the system, as well as how quickly they perform tasks.
- *Memorability.* Ease with which the user remembers the operation of the system after a period of time of not using it.
- *Error rate.* It is the number of errors made by users during the use of the system, focusing on the seriousness of these, as well as the ease with which they can recover after having made an error.
- *Satisfaction.* It implies how pleasant the use of the system represents for the user.

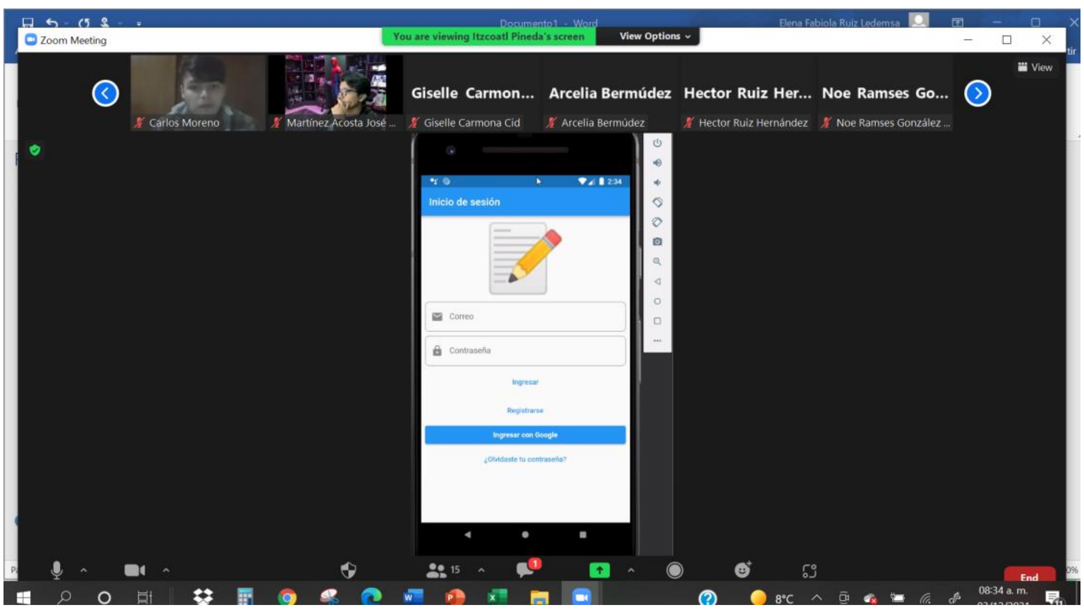
After the questionnaire, an interview was applied to 70% of the student sample, since they were the students who wanted to continue with the study.

The interview was structured with a total of four questions, whose answers were categorized according to a description that the interviewee assigned to the application around the gamification aspects with which it was built.

Results

To carry out this study, we worked with a group of 30 high school students, who worked with the application for two weeks in their free time, and at the beginning of the third week they solved the SUS questionnaire. It is important to point out that all instructions were given remotely using the Zoom platform (figures 14, 15 and 16). A question was added to the SUS questionnaire, which provided extra information about the application. The participants solved the questionnaire online through Google Forms. Excel was used for data analysis.

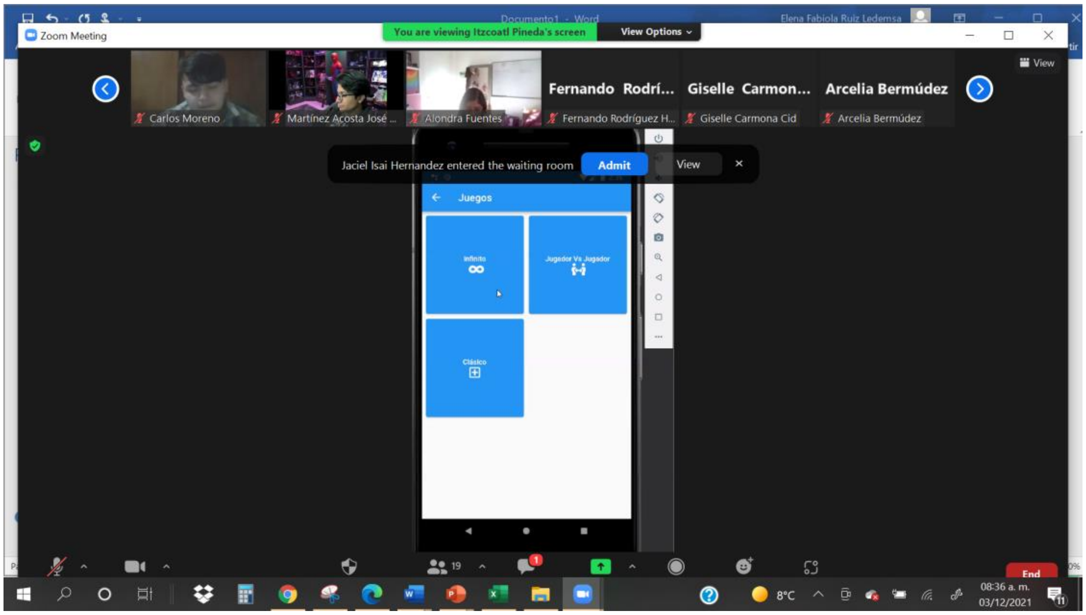
Figura 14. Explicación de la navegación por la aplicación



Fuente: Elaboración propia

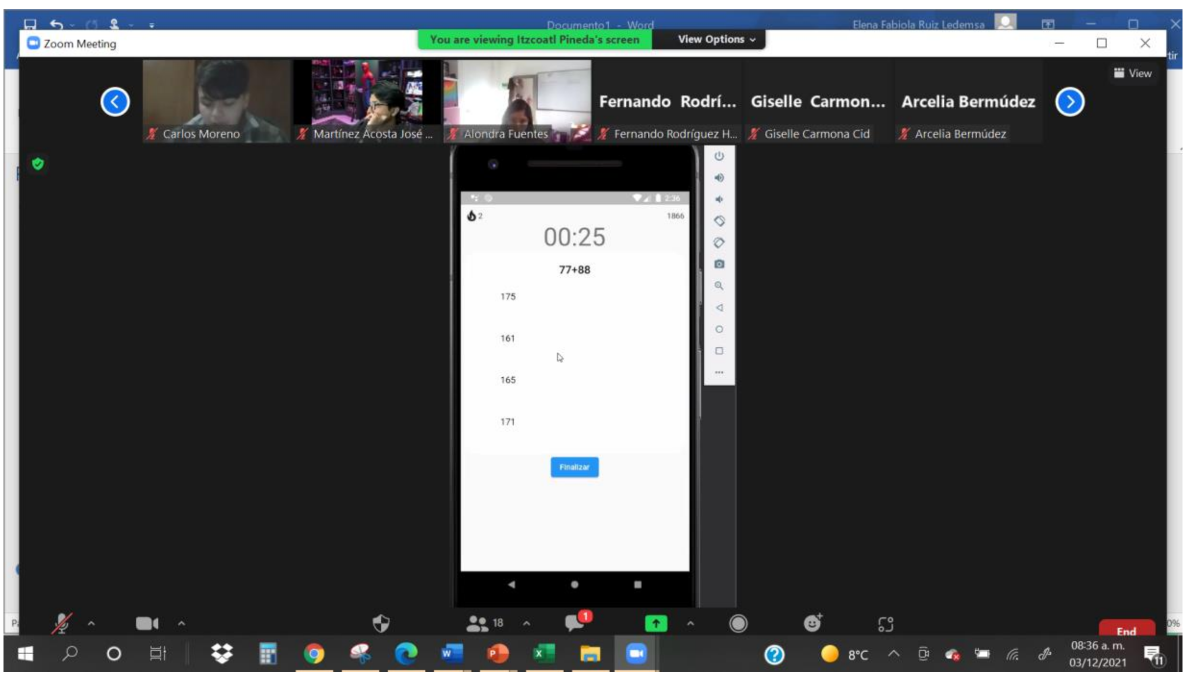
Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

Figura 15. Explicación de la realización de operaciones en la aplicación



Fuente: Elaboración propia

Figura 16. Explicación de la navegación por la aplicación



Fuente: Elaboración propia

After applying the questionnaire, the file generated by the Google Forms platform with a .csv extension was downloaded and converted into an .xls file to begin data processing. For the evaluation of the SUS questionnaire, first, formulas 1 and 2 were used to homogenize the data of the values initially obtained by the reagents of each question; Next, the results of each participant were added, and then multiplied by 2.5. The calculation was continued by adding the scores of the participants and averaging them.

Finally, the final result was compared with the classification of the evaluation ranges in the usability scale of the SUS questionnaire. And as a result, an acceptance score of 79.58 was obtained in relation to the usability that the participants had when working with the application, so it is in the "Good" range. Table 3 shows the values obtained.

Tabla 3. Valores de las respuestas a los reactivos del cuestionario SUS

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Suma	Producto con 2.5
2	1	2	2	2	4	4	4	2	3	26	65
2	1	3	4	3	4	3	4	2	4	30	75
2	1	4	4	2	4	4	4	1	4	30	75
2	1	4	4	3	4	4	4	0	4	30	75
2	2	4	4	4	4	4	4	3	4	35	87.5
2	2	4	4	3	2	4	4	2	4	31	77.5
3	4	4	4	3	4	4	4	4	4	38	95
3	0	4	3	3	3	4	4	4	4	32	80
2	4	4	3	3	4	3	4	4	3	34	85
3	3	4	3	3	4	4	4	4	3	35	87.5
3	4	3	4	3	4	3	4	3	4	35	87.5
3	3	4	3	3	3	4	4	4	3	34	85
3	1	3	1	3	4	3	1	3	1	23	57.5
2	3	2	3	2	3	3	4	1	3	26	65
2	4	3	3	3	2	3	3	3	2	28	70
2	2	3	3	4	4	4	4	4	3	33	82.5
4	4	4	4	4	4	4	4	4	4	40	100
1	4	3	4	2	3	4	4	4	4	33	82.5
2	1	2	2	2	4	4	4	2	3	26	65
											79.58

Fuente: Elaboración propia

With the previous result, four of the five quality components that integrate usability were evaluated, which are: Easy to learn, Easy to remember, Low error rate and Satisfaction. This information appears in Table 4.

Tabla 4. Cuestionario de SUS

Cuestionario de Escala de Usabilidad de Sistemas		
Clave	Preguntas	Atributo
R1	Creo que usaré esta plataforma o sistema frecuentemente.	Satisfacción
R2	Encuentro la plataforma o sistema innecesariamente complejo.	Memoria
R3	Pienso que la plataforma o sistema fue fácil de usar.	Memoria
R4	Pienso que voy a necesitar soporte técnico para poder usar esta plataforma o sistema.	Error
R5	Encontré varias funciones en la plataforma o sistema bien integradas.	Aprendizaje
R6	Pienso que hubo muchas inconsistencias en el sistema o plataforma.	Error
R7	Imagino que la mayoría de las personas podrían aprender a usar esta plataforma o sistema bastante rápido.	Aprendizaje
R8	Encuentro la plataforma o sistema muy molesto de usar.	Satisfacción
R9	Me siento muy seguro al usar la plataforma o sistema.	Satisfacción
R10	Siento que necesitaré aprender muchas cosas antes de que pueda utilizar correctamente la plataforma o sistema.	Aprendizaje

Fuente: Elaboración propia

The items that represent the Satisfaction attribute are R1, R8 and R9. Table 3 shows that students consider frequently using the application, due, among other factors, to the fact that it is safe and they feel comfortable with it. The score obtained is 3.3 for the frequent use of the platform, on a scale of one to five, where one is strongly disagree and five is strongly agree. The security that the use of the application causes them has a value of 3.7 and that of the pleasure that its use causes them is also 3.7, on the same scale of one to five. The scores obtained from the average exceed the value of three and the variability of the data with respect to the mean does not exceed one, so the level of satisfaction with the application is considered to be good.

Tabla 5. Valores estadísticos del cuestionario SUS

Clave	Promedio por Pregunta		Rango en la Evaluación
R1	3.33	0.77	De acuerdo
R2	1.78	1.22	En desacuerdo
R3	4.44	0.70	De acuerdo
R4	1.67	0.84	Muy en desacuerdo
R5	3.94	0.64	De acuerdo
R6	1.16	0.92	Totalmente en desacuerdo
R7	4.67	0.49	Totalmente de acuerdo
R8	1.22	0.73	Muy en desacuerdo
R9	3.689	1.28	De acuerdo
R10	1.61	0.85	En desacuerdo

Fuente: Elaboración propia

Regarding the Learning attribute, the reagents that evaluated it are R5, R7 and R10. The students in the sample consider that the learning curve of using the application is low due to the functions being well integrated, as well as the speed with which they learned to use the different components of the application. The values of the averages referring to a good integration of the functions and the speed of their use scored 3.9 each on a scale of one to five. Therefore, it is concluded that the way of working with the application is practically intuitive.

As for the Memory attribute, this was evaluated through items R2 and R3. The students in the sample agreed that the app was easy to use, scoring 4.4, and disagreed that the platform was unnecessarily complex, scoring 1.78 on the same scale used from one to five, so both results are considered good for the application.

Finally, the remaining reagents are R4 and R6, which evaluate the number of errors that can be generated when interacting with the application. The values obtained in the questionnaire were 1.67 and 1.16 on a scale of one to five, so it is interpreted that the students strongly disagreed about needing technical support and the fact that there were inconsistencies in the application.

Discussion

Based on the results obtained by the SUS questionnaire, the application is considered good in the sense that it complies with characteristics such as user satisfaction, it is practically intuitive as it does not require many explanations to be able to use it, they consider it useful for practicing addition, subtraction, multiplication and division operations; also because there are many exercises and since they are random it is difficult to find the same one twice during practice, so they would use it frequently. In order to delve a little into the usefulness it had and if the gamification elements used contribute to motivation when working with the performance of basic operations, interviews were carried out with the students who wanted to participate in this activity, which represented 70% of the students. students (n = 21). The interviews were conducted remotely using the Zoom platform. The questions formulated are shown in table 6, as well as the categories in which they were classified.

Tabla 6. Categorías de las respuestas de la entrevista

Pregunta	Categorías	Porcentaje
¿Qué es lo que más te gustó de la aplicación?	Porque asigna logros de acuerdo con el avance que se lleva y eso causa una emisión de satisfacción.	88.8 %
	Por la cantidad de ejercicios diferentes.	100 %
	Porque va por niveles y estos se desbloquean	100 %
	Porque te permite competir con otros compañeros	77.7 %
¿La consideras útil? Sí / No ¿Por qué?	Si	100 %
	Es útil porque se puede practicar muchas veces y no se repiten las operaciones, como para que se puedan memorizar.	88.8 %

	Va por niveles y cuando se pasa un nivel provoca satisfacción y seguridad en el estudiante.	100 %
	Es importante practicar porque en las clases no se permite usar el celular y se tienen que hacer las operaciones de forma mental.	100 %
	Permite usar diferentes estrategias para sumar, restar o multiplicar.	
¿Qué estrategias usaste para hacer más rápido las operaciones?	Estrategia de hechos derivados (mediante agrupaciones de sumas o restas conocidas).	100 %
	Empleo del retroconteo en la sustracción.	100 %
¿Te aburrió resolver operaciones con la aplicación? Sí / No ¿Por qué?	No. El tiempo es un factor que hace que esté atento y resuelva rápido la operación. EL tener logros provoca un sentimiento de satisfacción	100 % 100 % 88.8 %

Fuente: Elaboración propia

The explanations given by the students refer to some of the aspects raised in the introduction to this article, such as the fact that they require the use of strategies to perform operations faster, for example, the strategy of derived facts proposed by Fuson et al. to the. (1996) and by Orrantia (2017), who used both addition and multiplication, using the decomposition of numbers to obtain known combinations. In this regard, the students showed some examples: if they wanted to obtain the result of 38 + 27, they considered 30 + 20 = 50 and for 8 + 7 they decomposed 7 into 8 − 1, in order to have two equal numbers to add, which would be 8 + 8= 16 and at the end subtract the 1, which results in 15, to which they added the 50, and obtained 65.

Another strategy of derived facts that they used and that is explained by Fuson et al. (1996) consists of using the redistribution based on 10, which they used a lot in combinations in which one of the addends is nine, such as 9 + N or N + 9; in this case, the combination is decomposed to make one of the addends 10; thus, having 4 + 9, this operation can be decomposed into ([3 + (1 + 9); the 4 decomposes it into 3 + 1, in such a way that it adds 9 + 1, giving 10 and then adds the 3, obtaining 13 as a result).

In subtraction, they used both count-back and count-up strategies (Fuson et al., 1996). Some examples they used was that to subtract, for example 57 − 14, they first subtracted 50 − 14, considering that it was 50 − 20 = 30, but since it was 14, then 6 is added to 30 to reach 20 and it would be 36, but 7 remains to be subtracted from 36, so they break 7 into 6 + 1 and then group 36 − 7 = 36 − (6 + 1) = 36 − 6 − 1 = 30 − 1 = 29.

Regarding the aspects of gamification that were used in the application, the students consider that the fact that it was organized by levels made them visit it more frequently, because they feel good when they manage to unlock a level and reach a new achievement, which This coincides with what was pointed out by Gersten and Chard (2009) about the importance of activities being leveled, since it allows the student to set their own learning pace.

The application generated sensory learning through visual elements, which facilitated the understanding of the use of the application, according to what was pointed out by Outhwaite et al. (2019).

The three elements of gamification incorporated into the application (scoring system, achievements and leaderboard) allowed the student's commitment, since it motivated them to continue using the application, which coincides with what was indicated by Wiggins (2016).

Conclusions

With this project, it was possible to develop a technological-educational resource that can be used on any mobile device.

The development and implementation of the application had the objective of practicing operating skills in high school students, because, according to the reviewed literature, many of the students use the calculator even to perform very simple operations, which has caused the loss of this ability, which is required in solving different math problems. The same students recognized the usefulness of practicing basic operations, since they are required when solving problems. The practice allowed them to carry out operations in less time, by using different strategies, granting them a higher level each month, according to the score achieved.

Responding to the question asked at the beginning of the study, and based on the answers given by the students to the questionnaire and in the interview carried out, it was found that thanks to the gamification elements that were taken into account (scoring system, achievements and leaderboard) it was possible to maintain the interest of the students in the use of the application, which was revealed through the interviews carried out.

The use of the application by the students was observed in the leaderboard, because when users enter and play, according to the score obtained, they have a place in the leaderboard, which is seen in the Leaderboard option. .

It is important to note that the application can be downloaded from Google Play and is called Algorithmi. There you can play and review the achievements (in figure 17 a screenshot is shown where some names of the students who worked with the application appear).

Figura 17. Pantalla donde aparece la tabla de liderato

Fuente: Elaboración propia

The use of gamification elements such as the use of achievements and leaderboards, the competition mechanics, was considered excellent by the students because it helped them to continue practicing. In the interview they comment that time was a factor that allowed them not to get bored in solving the operations, as well as unlocking the achievements.

Future lines of research

Aspects that can be worked on in the future are: considering a larger sample of users who use the application for a long period of time to compare and analyze the use of the gamification elements that have the greatest impact on users and features they wish were added.

The application is scalable, so it is possible to add more exercises, difficulty levels, game modes and achievements to the system.

References

Alibali, M. W., Phillips, K. M. and Fischer, A. D. (2009). Learning new problem-solving strategies leads to changes in problems representation. *Cognitive Development, 24,* 89-101.

Barab, S. A., Gresalfi, M. and Ingram-Goble, A. (2010). Transformational Play: Using Games to Position Person, Content, and Context. *Educational Researcher*, *39*(7), 525-536.

Carpenter, T. P. and Moser, J. M. (2022). The Development of Addition and Subtraction Problem-Solving Skills. In Carpenter, T. P., Moser, J. M. and Romberg, T. A. (eds.), *Addition and Subtraction. A Cognitive Perspective* (pp. 9-24). Routledge.

Coronado, A. (2014). Estudio de prevalencia de dificultades de aprendizaje en el cálculo aritmético. *Bordón. Revista de Pedagogía*, *66*(3), 36-60.

Coronado, A. (2017). Academic resilience: a transcultural perspective. *Procedia - Social and Behavioral Sciences*, *237*(1), 594-598.

Derisma, D. (2020) The Usability Analysis Online Learning Site for Supporting Computer programming Course Using System Usability Scale (SUS) in a University, *International Journal of Interactive Mobile Technologies, 14*(9).

Fernández, A., Olmos, J. and Alegre, J. (2016). Pedagogical value of a common knowledge repository for Business Management courses. *@TIC. Revista D'Innovació Educativa, 16*(1), 39-47.

Fuson, K. C., Carroll, W. M. and Landis, J. (1996). Levels in Conceptualizing and Solving Addition and Subtraction Compare Word Problems. *Cognition and Instruction*, *14*(3), 345-371.

Fyfe, E. R., McNeil, N. M. and Borjas, S. (2015). Benefits of “concreteness fading” for children´s mathematics understanding. *Learning and Instructions, 35,* 104-120.

Geary, D. C., Brown, S. C. and Samaranayake, V. A. (1991). Cognitive Addition: A Short Longitudinal Study of Strategy Choice and Speed-of-Processing Differences in Normal and Mathematically Disabled Children. *Developmental Psychology*, *27*(5), 787-797.

Geary, D. C., Hoard, M. K. and Nugent, L. (2012). Independent contributions of the central executive, intelligence, and in-class attentive behavior to developmental change in the strategies used to solve addition problems. *Journal of Experimental Child Psychology*, *113*(1), 49-65.

Gelman, R. and Gallistel, C. R. (1978). *The Child's Understanding of Number*. Cambridge, United States: Harvard University Press.

Gersten, R. and Chard, D. (2009). Number Sense: Rethinking Arithmetic Instruction for Students with Mathematical Disabilities. *The Journal of Special Education*, *33*(1), 18-28.

Gresalfi, M., Martin, T., Hand, V. and Greeno, J. G. (2008). Constructing competence: An analysis of students' participation in the activity system of mathematics classrooms. *Educational Studies in Mathematics*, *70*(1), 49-70.

Gunnar, M. and Folkesson, A. M. (2012). ICT in preschool: friend or foe? The significance of norms in a changing practice. *International Journal of Early Years Education*, *20*(4), 422-436.

Hernández, R., Fernández, C. y Baptista, C. (2008). *Metodología de la investigación*. México: McGraw-Hill.

Hsin-Yuan, W. and Soman, D. (2013). *A Practitioner's Guide To Gamification of Education*. Toronto, Canada: University of Toronto. Retrieved from https://mybrainware.com/wp-content/uploads/2017/11/Gamification-in-Education-Huang.pdf.

Hunter, D. and Werbach, K. (2012). *For the Win*. United States: Wharton Digital Press.

Instituto Nacional para la Evaluación de la Educación [INEE]. (2018). *Planea. Resultados nacionales 2018. 6º de primaria*. México: Instituto Nacional para la Evaluación de la Educación. Recuperado de https://historico.mejoredu.gob.mx/evaluaciones/planea/resultados-planea/.

Johnson, L. (2020). *The NMC Horizon Report: 2020 Higher Education Edition.* Austin, United States: The New Media Consortium.

Larrazolo, M., Backhoff, E. y Tirado, F. (2013). Habilidades de razonamiento matemático de estudiantes de educación media superior en México. *Revista Mexicana de Investigación Educativa, 18*(59), 1137-1163.

LeFevre, J. A., Smith, B. L., Fast, L., Skwarchuk, S. L., Sargla, E., Arnup, J. S., Penner, M., Bisanz, J. and Kamawar, D. (2006). What counts as knowing? The development of conceptual and procedural knowledge of counting from kindergarten through Grade 2. *Journal of Experimental Child Psychology, 93*(4), 285-303.

Lewis, J. R. and Sauro, J. (2019). Item Benchmarks for the System Usability Scale Item Benchmarks for the System Usability Scale. *Journal of Usability Studies, 13*(3), 158-167.

Martin, R. C., Annis, S. M., Darling, L. Z., Wadley, V., Harrell, L. and Marson, D. C. (2003). Loss of calculation abilities in patients with mild and moderate Alzheimer disease. *Archives of Neurology, 60(11),* 1585-1589.

McGuire, P., Kinkie, M. and Berch, D. (2012). Developing Number Sense in Pre-K with Five-Frames. *Early Childhood Education Journal*, *40,* 213-222.

Moral, S. N., Sánchez, C. y Sánchez, M. T. (2021). Materiales digitales para el aprendizaje en la didáctica de la Aritmética: una experiencia en escenarios presenciales y virtuales en docencia. Ponencia presentada en el 8.º Congreso Internacional sobre Buenas Prácticas con TIC. Málaga, del 19 al 21 de octubre de 2021.

Mullis, I., Martin, M. O., Foy, P. and Hooper, M. (2016). *TIMSS 2015 International Results in Mathematics*. Boston, United States: TIMSS & PIRLS International Study Center.

Nielsen, J., & Mack, R. L. (1994). *Usability inspection methods*. New York: Wiley.

Organisation for Economic Co-operation and Developmen [OECD]. (2016). Low-Performing Students: Why They Fall Behind and How To Help Them Succeed. Paris, France: OECD Publishing. Retrieved from https://www.oecd-ilibrary.org/education/low-performing-students_9789264250246-en.

Organisation for Economic Co-operation and Developmen [OECD]. (2018). *PISA 2018 Results (Volume I): What Students Know and Can Do*. Paris, France: OECD Publishing. Retrieved from https://www.oecd.org/publications/pisa-2018-results-volume-i-5f07c754-en.htm.

Orrantia, J. (2006) Dificultades en el aprendizaje de las matemáticas: una perspectiva evolutiva. *Revista Psicopedagogía 23*(71), 158-180.

Orrantia, J. (2017). Marcadores nucleares de la competencia aritmética en preescolares. *Psychology, Society & Education, 9*(1), 121-134.

Outhwaite, L. A., Faulder, M., Gulliford, A. and Pitchford, N. J. (2019). Raising early achievement in math with interactive apps: A randomized control trial. *Journal of Educational Psychology*, 111(2), 284-298.

Prasad, K. and Rao, M. (2020). Enhanced Academicians Engagement: Evidence from Gamification Interventions in Higher Education Institutes. *International Journal of Engineering Technologies and Management Research*, *7*(9), 24-30.

Resnick, L. B. (1989). Developing mathematical knowledge. *American Psychologist*, *44*(2), 162-169.

Resnick, L. B. (2020). From Protoquantities to Operators: Building Mathematical Competence on a Foundation of Everyday Knowledge. In Leinhardt, G., Putnam, R. and Hattrup, R. (eds.), *Analysis of Arithmetic for Mathematics Teaching*. Routledge.

Robson, K. (2015). Is it all a game? Understanding the principles of gamification. *Business Horizons*, *58*(4), 411-420.

Rodríguez, M., del Castillo, H. y Arteaga, B. (2021). El uso de aplicaciones móviles en el aprendizaje de las matemáticas: una revisión sistemática. *Ensayos. Revista de la Facultad de Educación de Albacete*, *36*(1), 17-34.

Sánchez, S., Sicilia M. A. y Rodríguez, D. (2012). *Ingeniería de software. Un enfoque desde la guía SWEBOK*. México: Alfaomega.

Santoso, H., Schrepp, M., Kartono, R., Utomo, A. and Priyogi, B. (2016). Measuring User Experience of the Student-Centered e-Learning Environment. *The Journal of Educators Online, 13*(1).

Sauro, J. (February 3, 2011). Measuring Usability with the System Usability Scale (SUS). Measuring U. Retrieved from https://measuringu.com/sus/.

Secretaría de Educación Pública [SEP]. (2018). *Aprendizajes clave para la educación integral*. México: Secretaría de Educación Pública.

Segal, A. (2011). *Do Gestural Interfaces Promote Thinking? Embodied interaction: Congruent Gestures and Direct Touch Promote Performance in Math*. (Doctoral dissertation). Columbia University, New York City.

Siegler, R. S. and Jenkins, E. (2014). *How Children Discover New Strategies*. New York, United States: Psychology Press.

Sommerfeld, M. (2009). Taking Up Opportunities to Learn: Constructing Dispositions in Mathematics Classrooms. *Journal of the Learning Sciences*, *18*(3), 327-369.

Wiggins, B. E. (2016). An Overview and Study on the Use of Games, Simulations, and Gamification in Higher Education. *International Journal of Game-Based Learning, 6(*1), 18-29.

Zepeda, S., Abascal, R. y López, E. (2016). Integración de gamificación y aprendizaje activo en el aula. *Ra Ximhai*, *12*(6), 315-325.

Zichermann, G. and Cunningham, C. (2011). *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*. Sebastopol, United States: O'Reilly Media.

Rol de contribución	Autor(es)
Conceptualización	Elena Fabiola Ruiz Ledesma
Metodología	Elena Fabiola Ruiz Ledesma, Lorena Chavarría Báez, Karina Viveros Vela. (Igual participación las tres).
Software	Lorena Chavarría Báez (principal), Elena Fabiola Ruiz Ledesma (apoyo), Karina Viveros Vela (apoyo).
Validación	Elena Fabiola Ruiz Ledesma (principal), Lorena Chavarría Báez(apoyo), Karina Viveros Vela (apoyo)
Análisis Formal	Elena Fabiola Ruiz Ledesma (principal), Lorena Chavarría Báez(apoyo), Karina Viveros Vela (apoyo)
Investigación	Elena Fabiola Ruiz Ledesma, Lorena Chavarría Báez, Karina Viveros Vela. (Igual participación las tres).
Recursos	Elena Fabiola Ruiz Ledesma, Lorena Chavarría Báez, Karina Viveros Vela. (Igual participación las tres).
Curación de datos	Elena Fabiola Ruiz Ledesma (principal), Lorena Chavarría Báez(apoyo), Karina Viveros Vela (apoyo)
Escritura - Preparación del borrador original	Elena Fabiola Ruiz Ledesma, Lorena Chavarría Báez, Karina Viveros Vela. (Igual participación las tres).
Escritura - Revisión y edición	Elena Fabiola Ruiz Ledesma (principal), Lorena Chavarría Báez(apoyo), Karina Viveros Vela (apoyo)
Visualización	Elena Fabiola Ruiz Ledesma, Lorena Chavarría Báez, Karina Viveros Vela. (Igual participación las tres).
Supervisión	Elena Fabiola Ruiz Ledesma
Administración de Proyectos	Elena Fabiola Ruiz Ledesma
Adquisición de fondos	Elena Fabiola Ruiz Ledesma, Lorena Chavarría Báez, Karina Viveros Vela. (Igual participación las tres).