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Design of an app for smartphones for the teaching-learning of basic algebra through Algesquares

Diseño de una app para smartphones para la enseñanza-aprendizaje de álgebra básica a través de Algesquares

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Abstract

Algesquares is a different method from the traditional one, for the teaching-learning of Basic Algebra, it is inspired by the algebraic cards of Caleb Gattegno as well as other similar methods. The present work aimed to present the design of an application that works as a tool for students and teachers, seeking a dynamic experience between students and educators. Algesquares works with colored tiles, some positive, some negative, and a "play" board. Students will be protagonists of their own learning, advancing through different levels of difficulty, unlocking new challenges, accumulating points and keeping track of their progress; while the teachers will be able to carry out individual and general control of the groups under their charge. With this application, it is sought to capture the attention of the student, encouraging students to be self-taught, to be curious and ingenious to play with the tiles, achieving significant learning that will help them solve similar situations.

Algebra, Application, Tool, Teaching, Learning

Resumen

Algesquares es un método distinto al tradicional, para la enseñanza-aprendizaje de Álgebra Básica, está inspirado en las fichas algebraicas de Caleb Gattegno así como otros métodos similares. El presente trabajo tuvo como objetivo presentar el diseño de una aplicación que funcione como una herramienta para estudiantes y profesores, que busca una experiencia dinámica entre educandos y educadores. Algesquares trabaja con fichas de colores, algunas positivas, otras negativas y un tablero para "jugar". Los estudiantes serán protagonistas de su propio aprendizaje, avanzando por distintos niveles de dificultad, desbloqueando nuevos retos, acumulando puntos y llevando un registro de su avance; mientras los docentes, podrán llevar el control individual y general de los grupos que tenga a su cargo. Con esta aplicación, se busca captar la atención del estudiante, fomentando en los educandos a ser autodidactas, a ser curiosos e ingeniosos para jugar con las fichas, logrando un aprendizaje significativo que lo ayudará a resolver situaciones similares.

Algebra, aplicación, herramienta, enseñanza, aprendizaje

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Introduction

In our country, there are two disciplinary fields that have a lot of weight in the New Educational Model in Upper Secondary Education; study programs, reinforcement activities, extracurricular programs, training at the beginning of courses and remedial training at the end of the course, revolve around Communication and Mathematics. Both disciplinary fields seek to develop generic and disciplinary competencies, to meet the ideal profile of the graduate. In the case of Mathematics, the development of competences is not achieved only with the memorization of the concepts, as was previously customary; now the student has to analyze the information, reason it, separate what the problem requires and the data that are available, look for several alternatives of possible solutions, check if the solution that is given is effective and finally, acquire significant learning so that When faced with similar problems, the student knows how to deal with them.

Mexico has remained in places below the average, as far as education is concerned. The PLANEA test is used to evaluate last semester students in the area of Communication and Mathematics. The latest general results that the official website has registered are from 2016, which say that: 49.2% are in Level I, 30% in Level II, 14.4% in Level III and 6.3% in Level IV. Level I is defined as: "Students who are at this level of achievement demonstrate deficiencies in the development of knowledge and skills related to the basic disciplinary competencies expected of graduates of upper secondary education" [1] . The latter means that almost 50% of the student population in upper secondary is in level I or basic.

The rejection of mathematics that many students manifest is born or worsens precisely when they start algebra. The academic results that stem from the difficulties of algebra are disappointing. Precisely at the levels where the most formal study of algebra begins, it is where the greatest school failure is found [2]. The problem that students have when learning algebra, many times stems from the academic backwardness they have in previous levels, that is why the student must have solid knowledge in arithmetic so that algebra is not difficult to understand.

One of the main evidences of changes in educational systems is the presence of ICT both in the classroom and in curricular designs. One of the advantages of working with ICTs is creating virtual learning spaces, involving the student and the protagonist of their own learning. For teachers, a technological update and adaptation of ICTs to their teaching work is required [3]. Despite all the advantages that ICT can generate inside and outside the classroom, there are many taboos about its use in teaching, which is why many teachers do not trust them. Furthermore, many schools have limited or no access to these types of resources [4].

With the correct use of ICT, students move from a passive spectator role to being an active part in the teaching and learning process, acquiring skills and knowledge according to the skill and ability of each student. ICT has revolutionized the way of teaching in the classroom, and surely, it is only the beginning of something that will be more common in a few more years. One of the problems with mathematics is that on many occasions concepts were handled and learned that were not related to something real for the student; now through ICT, this has changed as students will be able to visualize and understand these concepts, through various representation systems [3].

Several methods that currently exist are based on the same Algesquares principle, with some notable differences. Algebra Tiles or Algebra Chips, Algeblocks, Bancubi and the Box of Polynomials, are some examples. Although they all handle the same principle, there are characteristics that distinguish each one, be it the area of mathematics to which it is focused, the variation in the size of the tiles, the board used or the variety of issues that it can solve. The present work aims to present the design of an application that works as a tool for students and teachers, seeking a dynamic experience between students and educators. Algesquares works with colored tiles, some positive, some negative, and a “play” board.

The development of this research work is divided into the following sections:

1. Methodology

Describe one by one the steps that make up the project.

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2. Results.

An analysis of the results obtained is carried out. Finally, it is determined if the main objective was fulfilled.

3. Acknowledgments

A special thanks to the people and institutions that allowed the development of this research.

4. Conclusions

It discusses the objectives successfully achieved and how this work contributes to the teaching of basic algebra.

Methodology

This project was carried out in the General High School "Ignacio Manuel Altamirano", located in the town of San Lorenzo, Xicotepec, Puebla (See Figure 1), with students of upper secondary education with previous knowledge of arithmetic.

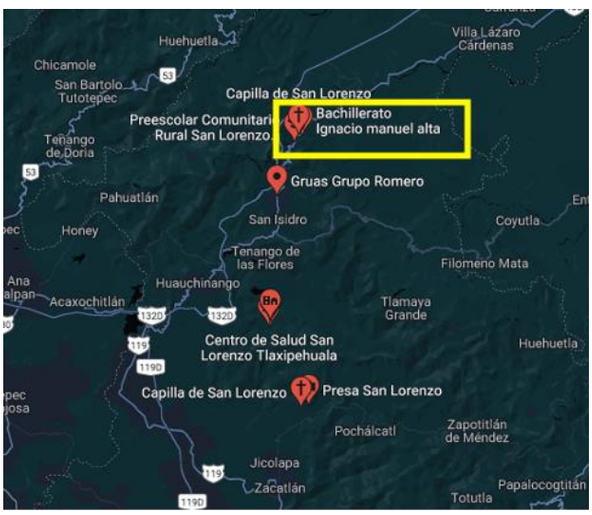

Figure 1 Location of the General Baccalaureate "Ignacio Manuel Altamirano", within the municipality of Xicotepec de Juárez, Puebla
Source: Google Maps

The use of Algesquares is oriented to the study of various Basic Algebra topics that belong to the Higher Secondary Education Study Program in Mexico. This method can develop various basic algebra topics such as reduction of like terms, multiplication of binomials, algebraic division, some notable product and factorization examples, as well as solving one of the types of quadratic equations.

The difference between Algesquares and the traditional teaching method is that the former makes use of colored tiles and a board to "play" to solve the proposed exercises [13].

There is a learning curve, as in any new process to learn to use this method. It may take a little longer for the student if they already have previous knowledge of algebra, so it is best for them to tackle these topics for the first time. In this way you will not have conflict to solve the exercises because you will not have in mind the traditional algorithm that involves each topic. If the student has well founded the basic operations seen in arithmetic, this method will be very easy to learn.

Algesquares uses colored tiles to solve algebraic exercises, each tile uses a different primary color; there are also positive and negative cards. The red chips represent the quadratic variable, the blue chips represent the linear variables, and the yellow chips represent the independent terms, as shown in Table 1:

Color/Sign:	Date:	Equals to:
Red		x^2
Red (-)	-	$-x^2$
Blue		x
Blue (-)	-	$-x$
Yellow		Independent term (I.T.)
Yellow (-)	-	I.T. negative.

Table 1 Table of equivalence between cards and algebraic language
Source: Own elaboration

The coefficients of each term determine the number of tiles to be put on the board and the exponent of the variable determines the color of each tile.

A. Analysis phase

1. ICT within the classrooms.

Technology can be seen as a tool easily incorporated into the classroom, in this regard, Wenger, Mc Dermott and Snyder (2002) argue the following points:

- Information and communication technologies (ICT) provide the opportunity to show the contents of a subject in different formats.

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- The use of ICTs in the classroom motivates and involves students in the teaching-learning process.

- ICTs provide teachers and students with the opportunity to communicate with each other in a synchronous and asynchronous manner, facilitating such communication, even over distance.

Even though the use of mobile devices can be carried out in the classroom and under face-to-face learning schemes, by involving technological tools in the educational process, it is possible to take advantage of most of the qualities that distance training allows, with the advantage of having the endorsement and support of a face-to-face strategy in the classroom.

2. Android Studio

Android Studio is the official Integrated Development Environment (IDE) for Android app development and is based on IntelliJ IDEA. In addition to IntelliJ's powerful code editor and developer tools, Android Studio offers even more features that increase your productivity when developing Android apps, such as the following:

- A flexible build system based on Gradle.

- A fast and feature-laden emulator.

- A unified environment where you can develop for all Android devices.

- App changes to push code and resource changes to the running app without restarting it.

- GitHub integration and code templates to help you compile common app functions and also import sample code.

- Variety of frameworks and testing tools.

- Lint tools to identify performance, usability, and version compatibility issues, among others

- Compatibility with C ++ and NDK.

- Integrated support for Google Cloud Platform, which facilitates integration with Google Cloud Messaging and App Engine.

3. Types of users

This project is focused on the educational sector, specifically on the subject of Basic Algebra for Upper Secondary Education. However, since Algebra is a fundamental tool frequently used in different branches of Mathematics, the application can be used as a support tool in any of these subjects. It can be used by:

- Students (14 to 17 years old): as a support material in learning different topics and basic concepts of basic algebra.

- Mathematics teachers: as a teaching tool, recording, monitoring and measuring student performance.

Considering that the majority of the public to whom the app is directed and the area in which the baccalaureate is located, as well as the socio-economic level of the students and the type of smartphone they use, it was decided to develop an application in Android Studio for devices running Android versions 4.2 or higher. Currently a low-end or medium-low-end device has at least Android version 7.0 or higher.

4. Requirements analysis.

In this part, the functions, services and operating restrictions of the system are established in detail.

Functional Requirements:

- Guide the user to solve algebraic exercises using Algesquares. The application should function as a learning guide for the student, so that he becomes familiar with the new method and through Algesquares, solves all kinds of algebraic operations, gradually increasing their level of difficulty.

- The type of exercises that can be solved by means of Algesquares are: addition and subtraction of like terms, multiplication of binomials, algebraic division, remarkable products (binomial squared and conjugated binomials), factoring (perfect square trinomial and difference of squares), Quadratic equations of the type: $a\,x\,\hat{}\,2 + b\,x = c$.

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- Automatically award points to the user for each exercise performed, depending on the level of difficulty and the type of exercise resolved. The user will be able to view their personal progress in the app.

- Have a section for the teacher to keep track of the individual and group progress of their students, levels taken and points obtained.

- At the basic level and intermediate level, the app will show prompts in the form of a guide for the user so that they can easily solve the exercises. While for the advanced level, these notices will be scarce and the user's freedom to choose the cards or to carry out certain processes, will be greater.

- Due to the type of two-dimensional matrices that the app handles, it is not possible to perform operations such as binomials to the cube, since three-dimensional figures are required to perform the operation.

- For the user's convenience in manipulating the elements on the screen, a survey of the maximum number of cards to work with Algesquares was carried out and the majority opted for a 6x6 matrix. Due to the above, the application will have reagents designed to work with a maximum of 36 cards.

No Functional Requirements.

- The requirements that do not specify the behavior of the system are:

- Performance: The application must perform its function in a fluid manner. The user experience must be pleasant to attract the attention of the students.

- Availability: The application must be available in the Play Store. Since there are several connection problems in the community where the high school is located, the application must work without an Internet connection.

- Usability: Any student with basic knowledge of arithmetic should be able to use Algesquares, without any type of restriction.

- Stability: If an error appears during the execution of the application, it must be able to handle it, register it and notify its developers of the error.

- Maintenance: Maintenance and new updates must be provided in order to improve the performance and usability of the app.

- Interface: It must be clear, intuitive and attractive to the user. It should not be forgotten that the main target audience is young people aged 14-17 who are studying at the upper secondary level.

- Integration. The application must be integrated with the entire Android operating system.

- Optimization. Take care of the loose processes that consume the battery, as this must be adequate. Make sure that the execution time is minimal while reducing the response times.

B. Design proposal

The application logo was made in Illustrator 2015 and several elements were taken into account for its design:

- Color chips. Algesquares does not perform any algebraic procedures with the traditional school method. Instead, use colored index cards so they are meaningful in the student's learning process.

- Basic colors. There are three distinctive colors for the tokens: red, blue, and yellow; these are related to different mathematical terms. These colors were considered as a reference to the primary colors.

- Symbology used. Within the logo tabs you can see symbols and letters related to mathematical terms.

- Neutral color. The gray color used in the Algesquares letters was for two reasons: one of them, to avoid saturating the logo with color, and two, to give the colored tiles more visual appeal.

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- Professional opinion. The opinion and guidance of a graphic designer was taken into consideration for the realization of the logo (See Figure 2).

Figure 2 Algesquares logo proposal
Source: Own elaboration

Here is a description of some of the application screen layouts:

- At the beginning of the application, the Algesquares logo will appear, which takes approximately 4 seconds and then changes to the home screen with a brief explanation of what the App does. Within this screen, there is a "Skip" button to that the user can enter the main menu (See Figure 3).

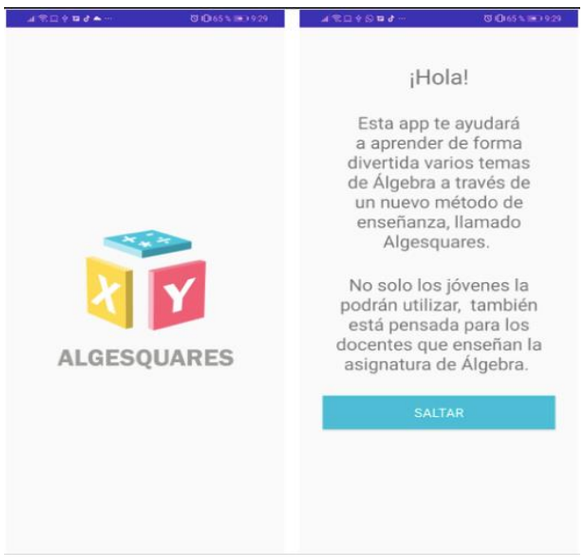

Figure 3 Initial screen of the application / Legend about the app.
Source: Own elaboration

1. In the Main Menu, the user will be able to choose any of the 8 themes of the Algesquares content (See Figure 4). Within each topic, there is a submenu with a basic, intermediate and advanced level.

Figure 4 Main selection menu. / Level selection menu
Source: Own elaboration

2. In the case of multiplication, once the level has been chosen, the user will determine the number of chips and the sign of each term of each binomial (See Figure 5).

Figure 5 Entry of the cards of both binomials in the Basic Level of Multiplication
Source: Own elaboration

3. In addition to the user guide messages, error messages will also appear in case of making a mistake in any procedure (See Figure 6).

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Figure 6 Error message that appears when entering the wrong number of chips in a binomial
Source: Own elaboration

4. Once the user enters the correct number of cards, the application will automatically create a matrix on the screen with the number of cards requested where they will have to follow the instructions on the screen to arrive at the correct solution for the exercise (See Figure 7).

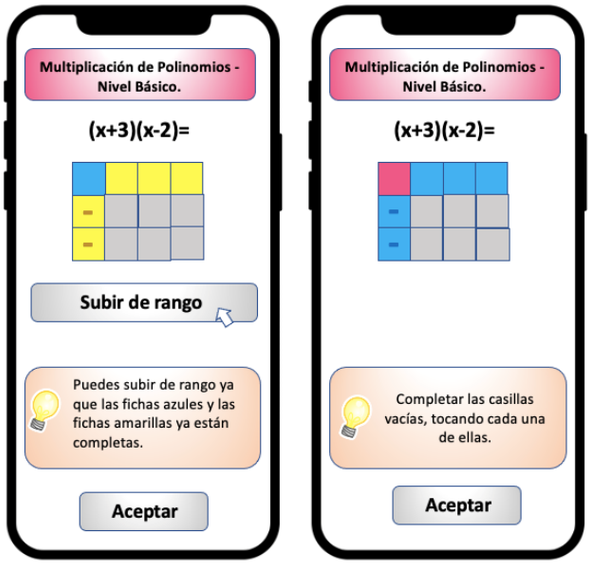

Figure 7 Example of a binomial multiplication exercise, basic level, solved by the Algesquares method
Source: Own elaboration

5. Once the user has followed the steps correctly, he must count the number of remaining tabs for the application to show him the final result (see Figure 8).

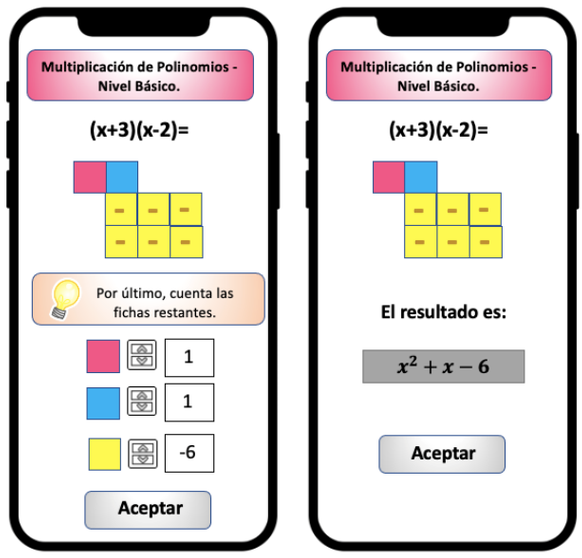

Figure 8 User entering the number of final cards / App showing the result
Source: Own elaboration

C. App design

At this stage, an analysis of the simulation results was carried out in order to detect any relevant error in order to make the necessary adjustments to the design. These analyzes gave the possibility of correcting some design and control details.

Results and Discussion

A survey was conducted to determine some application design issues and three different types of users were selected:

1. Experts in Information Technology.
2. Teachers in Higher Secondary Education.
3. High School Students.

Next, the questions of the survey carried out with the corresponding graph that contains the concentrated responses of the three types of users:

1. Select one or more options that you like about the Algesquares application logo (See Graphic 1):

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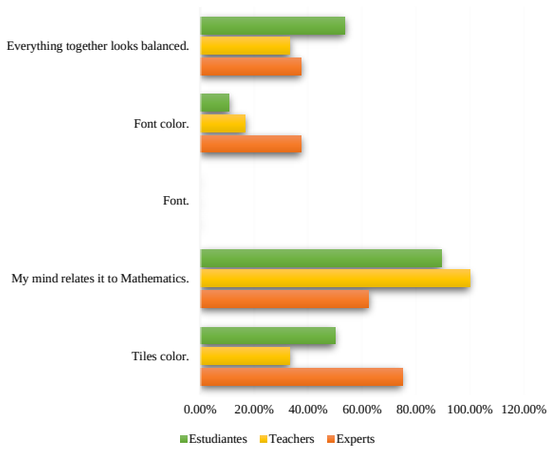
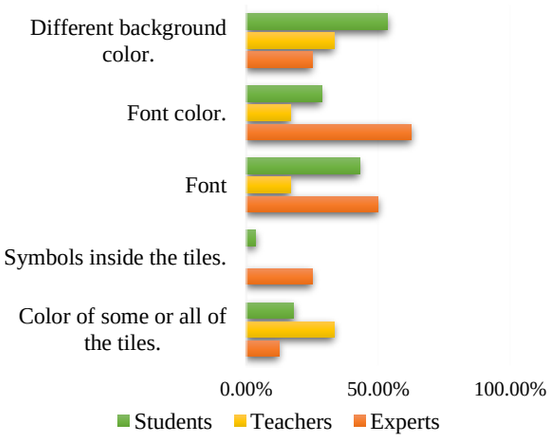


Graph 1 Statistic of question 1 of the app design survey
Source: Own elaboration

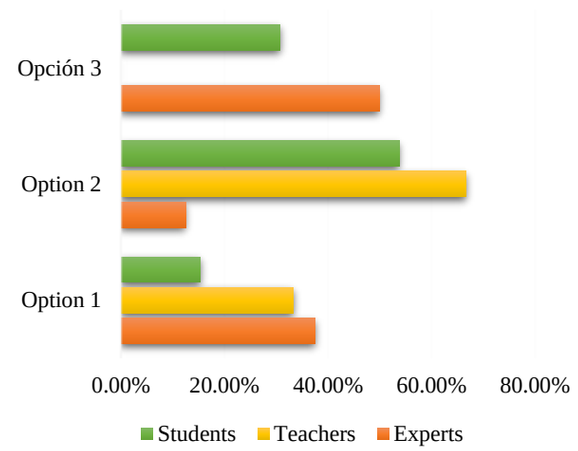
2. Select an option that you would change the logo (See Graphic 2):



Graphic 2 Statistic of question 2 of the app design survey
Source: Own elaboration

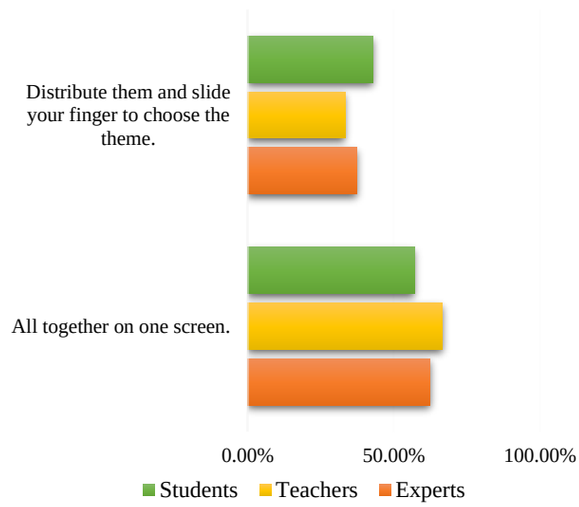
3. The colors of Algesquares are a variation of the primary colors (red, blue and yellow). Option 1 has the colors that the application currently uses (See Figure 9). Do you like those colors or do you prefer any other option? Take into account that, if any modification is made, the colors of the logo would also have to be modified (See Graphic 3).

Figure 9 Token color options shown in question 3 design survey
Source: Own elaboration



Graphic 3 Statistic of question 3 of the app design survey
Source: Own elaboration

4. The topics covered by Algesquares are 8 in total, which appear to choose from on your cell phone screen. Does the way in which the topics are presented seems correct or do you prefer that only some are shown and that you slide your finger to show the rest (so that the screen is not saturated)? The statistical results are shown in Graphic 4.



Graphic 4 Statistic of question 4 of the app design survey
Source: Own elaboration

5. Always the application will be playing with the characteristic colors of Algesquares (red, blue and yellow), as for example, in the menus, in the support texts, etc., in order for the user to adapt easily to these colors. Does this idea sound good to you?

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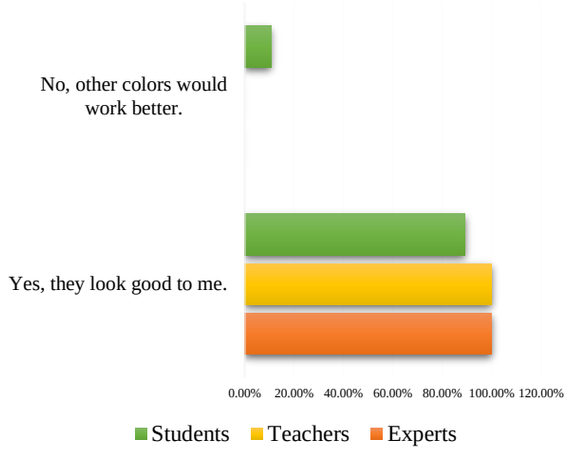
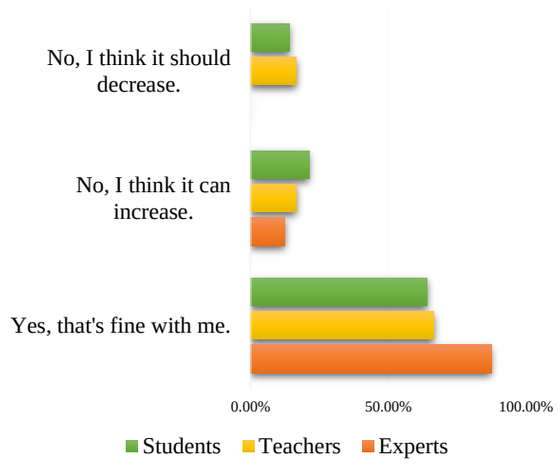


Graphic 5 Statistic of question 5 of the app design survey
Source: Own elaboration



Graphic 6 Statistical graph of question 6 of the app design survey
Source: Own elaboration

6. The application is still under development, so a preview cannot be shown, but considering the saturation of elements on the screen and the comfort of the user when working with said elements, it is planned to work with a maximum of 36 tabs on the screen (See Figure 10). This is an example of an exercise that uses the maximum number of chips, what do you think about it? (See Graphic 6).

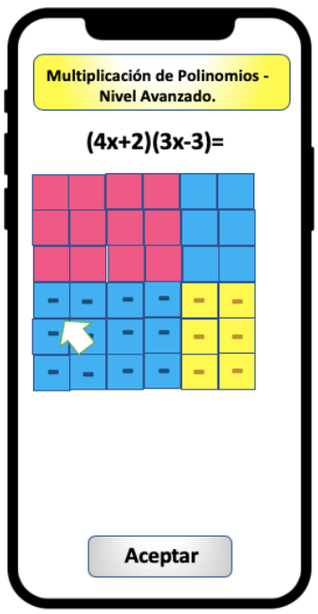


Figure 10 Shown example of an exercise using the maximum number of tabs on the screen - Survey of question number 3
Source: Own elaboration

The Algesquares concept was created in 2016. Over time, the topics shown in Table 2 were included, as well as a "student guide" mode and a "teacher" mode, which takes individual control and group of students. Next, methods based on the same principle as Algesquares are shown, pointing out their main characteristics, similarities and differences:

System	Algebra Tiles	Algeblocks	Polynomial Box
Year of creation	1950s	1996	2003
Basic Operations	Yes	Yes	yes
Factoring / Notable Products	Yes	Yes	Yes
Linear equations-one unknown	Yes	Yes	No
Quadratic equations $ax^2+bx=c$	Yes	Yes	No
Use tiles of the same size	No	No	No
It has an app or software	Yes/Playstore	Developing	Developing
Student learning guide	No	No	No
Control and supervision of groups for the teacher	No	No	No

Table 2 Comparison between the different basic algebra teaching methods that work under the same Algebra Tales principle
Source: Own elaboration

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Conclusions

Algesquares is a method that has evolved into a robust method that encompasses many of the specific contents related to algebra in the New Educational Model of Higher Secondary Education. It started as a classroom support material with limited topics and exercises; now, more topics have been added, more variety of exercises and the application is under development. As initially planned, the teacher will now be able to incorporate the teaching method into class planning and incorporate the use of ICTs through the use of the application, resulting in a community, not only physical, but virtual, of learning. that in times like the ones we live in at this time due to the global pandemic, distance education is essential.

As part of the improvements, the part of the teacher where the individual and group registration of students is kept has yet to be designed. More algebra topics could also be included in the future, increasing the capacity of cards and the complexity of the exercises, etc. The application is open to add improvements and functionalities as necessary, you can even consider topics from other branches of mathematics such as algebra or plane geometry.

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