REVISTA CÁTEDRA

Diseño de una aplicación móvil educativa a través de app inventor para reforzar el proceso de aprendizaje en operaciones con números enteros

Design of an educational mobile application through app inventor to reinforce the learning process in operations with whole numbers

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Resumen

En la actualidad el desarrollo e implementación de nuevas tecnologías se ha vuelto necesario en todos los ámbitos, en la educación nace con la obligación de utilizar nuevas herramientas que ayuden a potenciar el aprendizaje. En esta propuesta se analiza el impacto de una aplicación móvil educativa diseñada en la plataforma App Inventor, que busca ayudar a reforzar el proceso de aprendizaje de operaciones de números enteros. Se aprovechó la facilidad de manejo que presenta la plataforma online gratuita, para estructurar de manera llamativa todo el contenido acorde al nivel académico del usuario.

Así, se desarrollaron varias pantallas en la aplicación que lleva por nombre MatEstudio, cada una de estas pantallas sirven para fortalecer el proceso de aprendizaje. Estas pantallas se conforman por teoría, simuladores y un juego que en conjunto ayudan al razonamiento y retención del conocimiento. Se determinó el nivel de conocimiento teórico matemático y en Tecnologías de la Información y Comunicación de estudiantes de Educación General Básica. Posteriormente se aplicó una encuesta, en la cual, con base en los resultados obtenidos, se pudo evidenciar que se presenta una problemática para la correcta comprensión de la teoría y práctica de operaciones con números enteros. De esta manera se pudo concluir que es factible la implementación de una App Educativa creada en App Inventor para reforzar el proceso de aprendizaje de operaciones con números. No obstante se presentan varias limitantes entre las principales el acceso a la red y la mala utilización del programa por parte del usuario.

Palabras clave
App Inventor, gamificación, aprendizaje, números enteros.

Abstract
At present the development and implementation of new technologies has become necessary in all areas, in education it is born with the obligation to use new tools that help to enhance learning. This proposal analyzes an educational mobile application designed on the App Inventor platform, which helps to reinforce the learning process of whole number operations. The ease of use of the free online platform was used to structure all the content in a striking way according to the academic level of the user. Thus, several screens were developed in the application called MatEstudio, each of these screens serves to strengthen the learning process. These screens are made up of theory, simulators, and a game that together help reasoning and knowledge retention. The level of theoretical mathematical knowledge and in Information and Communication Technologies of students of Basic General Education was determined. Subsequently, a survey was applied, in which, based on the results obtained, it was possible to show that there is a problem for the correct understanding of the theory and practice of operations with integers. In this way, it was concluded that it is feasible to implement an Educational App created in App Inventor to reinforce the learning process of operations with numbers.

Keywords
App Inventor, gamification, learning, whole numbers.

1. Introduction
The creation of mobile applications through App Inventor for education has grown exponentially in recent years, leaving a little aside the use of a large number of books or other materials. Regarding the platform, Almaraz et al. (2016) mention "App Inventor technology has been revealed as an accessible and powerful tool to become familiar with the creation of mobile applications. Its potential for the creation of didactic content applications is remarkable" (p. 83). Being a free website, it is available to the entire educational community, it presents an intuitive management structure that helps for the publication of various applications in different areas or purposes. The App Inventor website, through its interface, creates files with apk extension (file format for a specific system or program) based on the Android Operating System. To complement, Borrego (2012) mentions that "an Android OS is present in mobile devices such as smartphones, watches, cars, tablets and televisions" (p.2). Being present in the different devices, it results

a point in favor since the great part of users has this type of software in their mobile. Thus, Statista (2018) complements that "Android is consolidated as one of the most used operating systems in the world for smartphones with more than 2000 devices in the world and more than three million applications" (p.1). In general this operating system is more accessible compared to IOS and Microsoft, due to the large number of free applications that can be found.

It is important to adapt new learning methodologies based on mobile applications, due to the fact that a basic level of knowledge is evident with respect to the area of Mathematics. Therefore, EL UNIVERSO (2019) writes "70.9% of students in Ecuador did not reach level 2 in Mathematics, categorized as the basic performance level" (p.8). The statistics demonstrate a scarce knowledge of Mathematics basics in students, aspects that will later present learning difficulties for much more complex elements. To complement the statistics of the PISA-D test conducted in 2018, Radio Huancavilca (2019) writes "In Ecuador, 49 % of students reached the minimum level of Reading Proficiency, 29 % in Mathematics and 43 % in Science" (p.1). We observe that the level shown by the students is worrisome, this in three subjects that are essential for the student's future.

The idea of this research stems from the need to apply new learning methodologies focused on the use of mobile applications. Thus, gamification is included as a point of evaluation and reinforcement of knowledge. To deepen the term, Gaitán (2013) defines "Gamification is a learning technique that transfers the mechanics of games to the educational-professional field in order to achieve better results (p.1). By presenting a dynamic mechanics, the attractiveness of the mobile application is increased, as well as its purpose is enhanced.

This article is structured as follows. In section 2 with previous works obtained based on the bibliographic research of web sites. Section 3 presents concepts related to the present study. Section 4 shows the methodology implemented for the correct development of the research work and the results of accessibility to mobile devices and applications by students. Section 5 shows the technological proposal. Finally, section 6 closes with the conclusions obtained based on the results.

2. Related work

A study in 2015, at the University of Salamanca "Spain" proposes a teaching innovation focused on the application of App Inventor for the creation of didactic applications for mathematics. In the results obtained from 17 students it is verified that 64% feel attraction for the subject and 41% ensure a change in their attitude towards mathematics. The authors conclude that App Inventor technology is accessible and powerful for the creation of didactic content applications that help to improve the attitude and learning of students (Almaraz, et al. 2015).

A technical project in 2016, proposes the design and implementation of a mobile application that facilitates the language learning process of children with Down Syndrome of the FASINARM Foundation of Guayaquil. Acceptance tests were conducted by the children for the application where the results were totally positive. According to the results obtained, the authors conclude that the application has been beneficial for the children of the initial level II, since it has favored them in the learning process (Aranda and Samaniego, 2016).

In 2017, a research is produced at the Polytechnic University "Venezuela" to observe the feasibility of implementing the App Inventor tool for learning algorithms, the study is conducted taking into account students of the Computer Engineering career. The results corresponding to the learning need show that the way of demonstration and the scope of

learning are important for the student. Likewise, in the Table of devices most used by the student, the cell phone is highly weighted. Therefore, the authors conclude that the App Inventor tool is feasible to use as a learning tool within the curricular unit (Jiménez and Larrea, 2017).

An investigation in 2018, seeks introductory learning of computer programming using App Inventor in an Institute in Guatemala. A diagnostic evaluation was performed to 18 students where 4 different situations were presented where with 33% is the highest value achieved, after taking the course the valuation obtained is 55% evidencing an improvement. From the results the author concludes that the introductory course using App inventor has favored the development of critical thinking and reasoning in students (Valdez, 2018).

In 2018, a teaching innovation project at the University of Cadiz "Spain" develops the App VectorialZ for interactive visualization of graphics created with software based on App Inventor. Acceptance aspects were collected through a survey of 24 students, where the results were positive in acceptance and usefulness, in addition it is evident that most users entered the App outside class hours. The authors conclude that the evaluation of the VectorialZ App is promising since most students highlighted that it facilitates the learning of content (Listán, et al. 2018).

In 2018, in Colombia, a virtual object for learning operations addition and subtraction of integers is presented. The tests conducted had two groups, the first one worked with the traditional learning model presenting poor results, while the second group used the virtual learning object, obtaining a better weighting. Based on the results, the author concludes that the virtual object obtained better academic results both in the understanding of the operations and in their use for the solution in similar situations (García, 2018).

In 2018, a learning proposal for students of the 21st century, a collaborative project based on App Inventor, is presented at the Public University of Navarra "Spain". In the survey of 42 students, 40% see programming using this tool as difficult, also 95.2% believe that it is important to make new versions of mobile applications. The author concludes that the project meets the expectations, since the use of the mobile device helps the student to create active learning fostering real knowledge away from passive learning (Sanz, 2018).

In 2019, a technological tool for the playful learning of mathematics is proposed at the Universidad Tecnológica Indoamérica "Ecuador". Through the survey conducted to students it is observed that 65% show low academic performance in mathematics and 85% are open to learning through the mobile application presented. Through the results the author concludes that the application meets the objectives since it enhanced the significant development and in turn strengthened the acquisition of skills with performance criteria (Pérez, 2019).

3. Related Concepts

3.1 Learning

Learning is interrelated with the term teaching, since it is broken down in one way or another from it. To complement, Sanchez (2003) defines learning as "a process of an extremely complex nature, whose essence is the acquisition of new knowledge, skill or ability" (p. 9). This acquisition of knowledge is carried out through different means, with the main objective that it is not a passing retention. This knowledge, in order to be considered learning, must help in the future to solve the problems of everyday life.

3.2 Meaningful learning

Currently, meaningful learning is very important for human beings, for the creation and construction of new knowledge. According to Ausubel (1983), learning is meaningful when:

> Content is related in a non-arbitrary and substantial (not verbatim) way to what the learner already knows. By substantial and non-arbitrary relationship it should be understood that the ideas are related to some specifically relevant existing aspect of the learner's cognitive structure, such as an image, an already meaningful symbol, a concept or a proposition (p. 2).

When mentioning a cognitive structure, it refers to the understanding and memory that make up the structure of a person's knowledge. That is to say, the ideas jointly related, in reference to a knowledge and knowledge of a certain subject or concept.

3.3 Mobile Application

A mobile application (App) is any program that can be found on a mobile device or tablet. In this regard, Enriquez and Casas (2013) point out that:

> Mobile application is software developed for mobile devices. Mobile refers to being able to access data, applications and devices from anywhere and at any time. This type of applications are developed taking into account the limitations of the devices themselves, such as low computing power, low storage capacity, limited bandwidth, among others (p.35).

Each of the mobile applications installed on a mobile device has a series of requirements, depending on the purpose of the program. The requirements are based on the storage size that varies according to the amount of graphic content such as: images, sounds, videos, among others.

According to Artica (2014), he mentions that: "applications are born from some specific need of the users, and are used to facilitate or allow the execution of certain tasks in which an analyst or a programmer has detected a certain need" (p.3). Each of the needs serves to facilitate the fulfillment of an activity and based on their purpose Medina (2018) encompasses them as follows as shown in Figure 1:

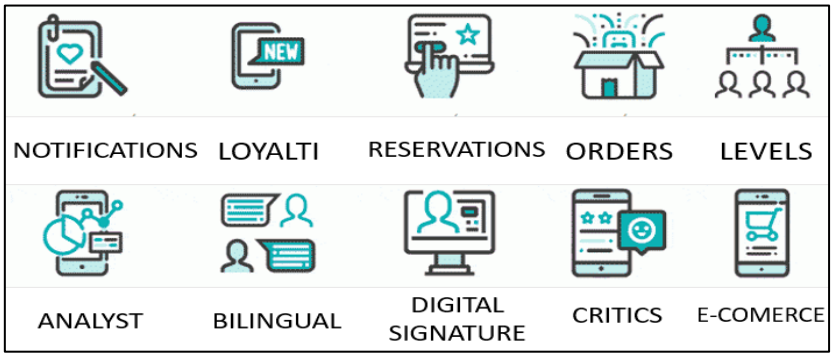

Figure 1. Types of mobile applications (Medina, 2018, p. 1).

All mobile applications comply with specific features and functions according to their purpose of creation. Each one of them satisfies the need presented by the user in various fields. Among the group of applications, the use of mobile applications for purposes such as: entertainment, work, leisure, communication, health, etc., is reflected in the use of mobile applications.

3.4 App Inventor

It is a free web space that encourages content creation. The official MIT App Inventor website (2012) defines it as "a visual and intuitive programming environment that allows everyone, including children, to create fully functional applications for smartphones and tablets" (p.1). With the above mentioned, it is known that App Inventor[The access address to App Inventor is: http://ai2.appinventor.mit.edu] is simple to use and helps in designing Android applications for different purposes of everyday life.

These purposes can be for work, leisure, news, education, among others, depending on the purpose sought by the creator. In this regard, Posada (2008) mentions that "it offers its users an interesting technological solution with which to create Apps for Android devices in a simple way" (p.3). This web media, being a new digital gateway for children, youth and adults, wants to eradicate the consumption of technology and seeks to promote the creation of technology.

The creation and innovation of technology helps the user, since it benefits the logical thinking of the creator at the time of the design of each of the applications. These Apps being compatible with Android can be easily installed on any mobile device that has this operating system.

3.5 Gamification

Within the educational field, the application of new methodologies to improve student learning can be evidenced, one of them is gamification. A term that Gaitán (2013) defines as:

> A learning technique that transfers the mechanics of games to the educational-professional environment in order to achieve better results, either to better absorb some knowledge, improve some skill, or reward specific actions, among many other objectives (p.1).

In view of the above, several elements can be used as an educational resource to make games that help stimulate the student to solve problems and build critical thinking through a problem of everyday life.

3.6 Whole numbers

Integers are born, by the idea of facilitating calculations with respect to numbers that are below zero and obtain more accurate results to reality. According to Rumiche (2019), he defines that "the need to represent quantities less than zero, and to make subtraction always possible motivated the creation of the set of integers (Z)" (p.17). Thus, Z integers are made up of the following components and symbols: positive integers (), negative integers () and zero. Once the learning definitions are clear, the following is an orderly list for the correct learning cycle of integers.

1. Preparation of basic topics for the study of integers.
2. Provide resources and materials containing theory and properties with integers.
3. The student reviews and grasps each of the operations presented.

4. Assimilation of the information and putting it into practice in exercises and application problems.

In each of the stages each educational actor plays an important role, in the first instance the teacher who is the one who guides so that they comply with what has been proposed. On the other hand, the student is the one who receives each of the knowledge, to later put it into practice. This is achieved by means of educational resources, which serve as a bridge for the teacher-student relationship.

4. Methodology

The research work was carried out using the methodology described below.:

- **Approach:** The research work was carried out through a mixed approach (qualitative and quantitative), due to the identification of the evident problems in the learning of Mathematics, specifically in the resolution and comprehension of operations with integers. All this information was based on measurable data collected in the educational institution through an instrument previously validated by research experts. To complement according to Hernandez (2014) "The mixed approach constitutes a possible choice to face research problems and is equally valuable. It is, so far, the best way designed by mankind to investigate and generate knowledge" (p.2).
- **Type of research**: The project will use a field research; through, the collection of data coming from the surveys elaborated in the area of Mathematics. This instrument is directed to students in the eighth grade of General Basic Education at the Eugenio de Santa Cruz y Espejo Basic Education School.
  Documentary research will also be used for the elaboration of the theoretical framework, based on the collection of information. All data will be selected through a search in different documentary sources, which will serve to complement the information of the object of study.
- **Level:** Hernández (2014) mentions "exploratory studies are carried out when the objective is to examine a topic or research problem that has not been studied much, of which there are many doubts or which has not been addressed before" (p.91). Thus, for the elaboration of the research work, the exploratory level was chosen, since mobile applications were little known and explored in the educational institution. Specifically, their use as a didactic resource for learning mathematical operations with integers through interactive and innovative activities.
  At the same time, the descriptive level was used, allowing to appreciate the real state of the eighth grade in their mathematics education, especially in the understanding and resolution of operations with integers. This assessment helped to examine the educational environment, the didactic resources available in the institution and some of the learning difficulties. And thus find a solution through the design of an educational mobile application through App Inventor; which serves as an innovative pedagogical tool for the student. Based on the aforementioned Hernández (2014) notes that "with descriptive studies we seek to specify the properties, characteristics and profiles of people, groups, communities, processes, objects or any other phenomenon that is subjected to analysis" (p.92).
- **Technique:** The survey was chosen as the technique for obtaining information and data for this research. This survey will be conducted online, with the help of the online platform Google Forms.
- **Instrument:** The questionnaire was conducted taking into account factors of composition and coherence within the mobile application. Based on the above, the

questionnaire presented contains 15 questions, where your choice is composed of 2 answers, one positive and one negative. In which the options YES APPLIES or NO APPLIES can be observed, according to the user's perspective.

- **Validity:** For the validity of the data collection instrument, we had the help of two teachers from the Faculty of Philosophy, Letters and Educational Sciences of the Pedagogy of Experimental Sciences and Computer Science career. A matrix was used to analyze the correspondence, quality and language of each of the items.

4.1 Population and sample

In the present research project, the selected population is composed of eighth grade students of the Eugenio de Santa Cruz y Espejo School of Basic Education. Table 1 shows exactly how many students were selected for the survey.

Population	Quantity
Eighth Grade EGB "A	33
Eighth grade EGB "B	31
Eighth grade EGB "C	30
Total	94

Cuadro 1. Población Octavo EGB

4.2 Results

The results presented in the statistical graphs in Figure 3 correspond to the first five items of the questionnaire applied. The questions are focused on the ease of use of the educational mobile application from the user's point of view.

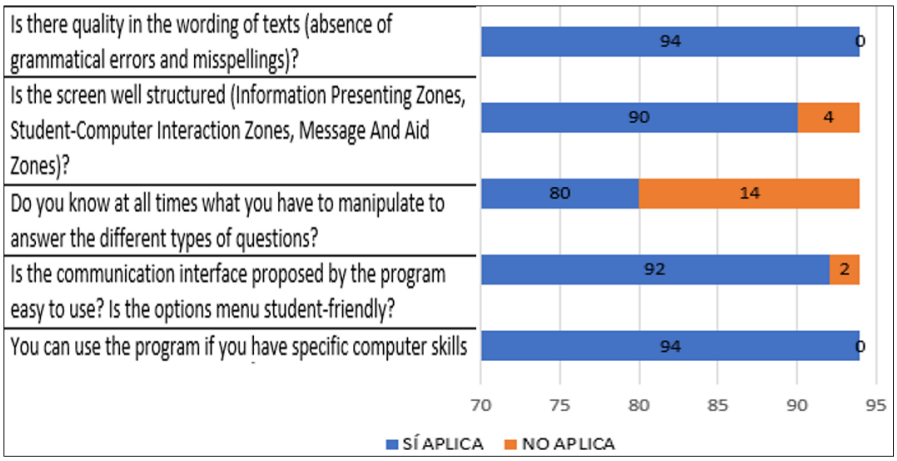

Figure 2. Program utilization results

Based on the results of the first section, there are positive aspects regarding the ease of manipulation of the tool by the student. Likewise, it is established that the design and its components are mostly very well structured, since they allow its handling to be intuitive and interesting for the student.

Figure 4 shows the next block of questions, related to aspects of visualization within the educational mobile application. This has to do with elements, shapes, sizes, colors, among others that make up the virtual environment of the program.

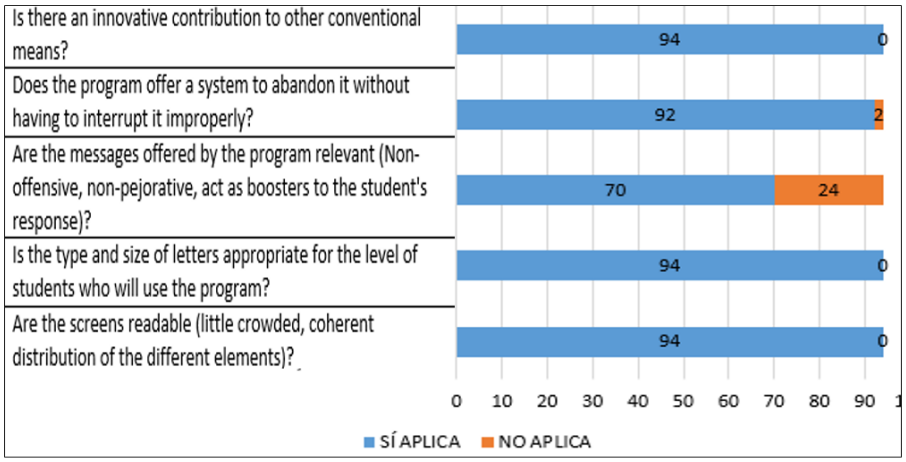

Figure 3. Display results per screen

The results show mostly positive responses regarding the conformation and structuring of the content and its form within the Mobile App. Only a small part of the population does not consider the relevance of some elements, as well as suggesting the inclusion of other action buttons for easier navigation between screens.

In the last section of the questionnaire, Figure 5, we found items that were directed to the interaction that exists between the user and the application as such. This in order to demonstrate that learning will not be fleeting, but dynamic and innovative.

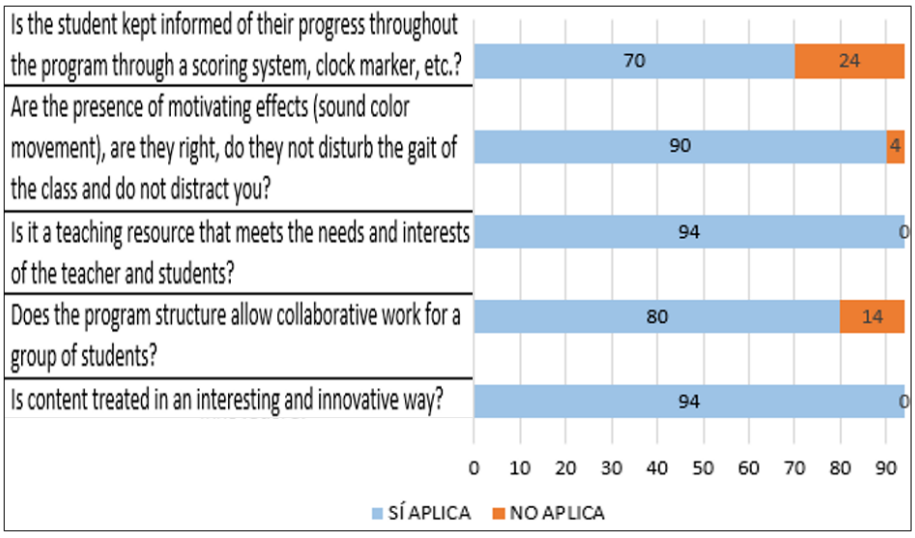

Figure 4. Results of interaction forms

Based on the results obtained in the main questions of the survey, it is evident that most of the students' answers favor the technological project. Thus, taking into account all the users' opinions, an educational mobile App has been built to meet the needs of the level of knowledge to which they belong. Contributing with a memory game, which allows the student to put into practice the knowledge studied in the educational mobile application.

5. Implementation

For the correct installation and operation of the MatEstudio application, the mobile device must have the minimum requirements detailed in Table 3. This is to avoid failures in the course of program operation, as well as visualization failures in the final design in some devices that do not have these characteristics.

Operating System	**Android Version 7 or higher**
Storage	**12.5 MB of free memory**
RAM	**1.6 Gb or higher**
Display	**640 x 1136**

Table 3. Required Program Components

To access the application, the MatEstudio.apk file was uploaded to the Google Drive storage system as shown in Figure 6. Through the Internet, the user is directed to the corresponding file storage link 1.

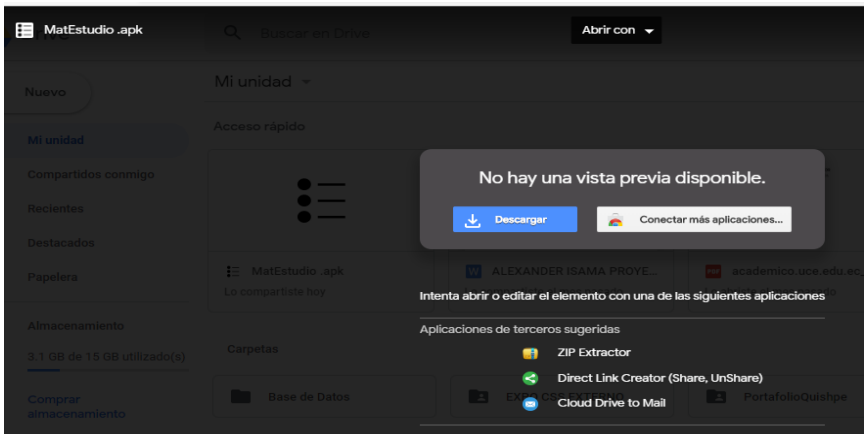

Figure 5. Program download site

The application as such presents different screens, all of them eye-catching and with dynamic colors to attract the user's attention. Figure 7 shows the above mentioned, we have the Welcome screens and the menu where the user decides which of the operations he/she wants to enter to see its content. As can be seen, there are 8 screen options, which contain each of the essential mathematical operations, as well as a general introduction to the subject and finally the game mentioned above.

Figure 6. Welcome Screen and Menus

Next, when you are already inside any operation, there are submenus that present theory, properties and simulators of the indicated operation. Figure 8 shows the content and the operation simulators where the knowledge already studied can be put into practice.

Figure 7. Theory and Simulators Screen

Finally, in order to put into practice the knowledge seen in each of the screens, a memory game has been included. Figure 9 shows that it is composed of 16 action buttons in which the student has a time limit to solve it.

Figure 8. Game Screen

The new system has a memory game screen in order to better stimulate and motivate the use of the mobile application to reinforce the learning of integers. This section contains part of the theory of the different mathematical operations, but which are put into practice at the time of solving a proposed exercise.

6. Conclusions

With the present research it has been possible to design in an innovative way a new technological educational tool, made up of dynamic elements within an educational environment that help learning. In addition, it was possible to verify the economic and technological feasibility for the study of operations with integers through an educational mobile application. For this purpose, several screens with attractive content and colors were designed, as well as the inclusion of a game within the same program in order to meet all the needs of the student, according to the level of education to which he belongs.

The use of mobile applications is currently in full trend, the possibility of taking advantage of each of them depends on the good management of the same made by each user. This following tutorials and user manuals, to make the most of each of the operations that allow us to perform this type of mobile programs.

Mobile applications, like any other created program, can bring variants and improvements with the passing of time. Based on follow-ups and evaluating the results of use, changes can be made in the structure as well as in the content of the application, in order to provide a quality product that can be expanded to more groups of users.

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