Article **Journal of Technological Engineering**
June, 2023 Vol.7 No.19 1-8

Development of mobile apps for use in mathematics

Desarrollo de aplicaciones móviles para su uso en matemáticas

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DOI: 10.35429/JTEN.2023.19.7.1.8 Received March 14, 2023; Accepted June 29, 2023

Abstract

This work shows the development of three mobile applications with Android system. These apps have the purpose to practice, through play, some mathematical concepts that are important for engineering students. The gamification on mobile devices can be used as a didactic tool in face-to-face learning and e-learning. The use of mobile devices is very common today in society. This allows us to take advantage of them to generate active learning in different areas. Were considered by the development of the applications next steps. First, the general requirements of the game. Then, mathematical concepts that will be used in apps. Next, building the app. And finally, the tests and implementation of these with engineering students. The results of the test and implementation show that the applications were functional for the students. However, these apps have opportunities for improvement, mainly in the interface whit the aim to have, for example, better interactivity.

Mobile app, Mathematics, Active learning

Resumen

El presente trabajo muestra el desarrollo de tres aplicaciones para móviles con sistema Android, que tienen la finalidad de poder practicar, mediante el juego, algunos conceptos matemáticos que son importantes para los estudiantes de nivel superior, principalmente de ingeniería. Esto en el entendido de que la gamificación en dispositivos móviles se puede utilizar como herramienta didáctica tanto en ambientes presenciales como virtuales, ya que el uso de estos dispositivos es frecuente hoy en día en la sociedad, esto permite aprovechar dicha herramienta tecnológica con el fin de generar aprendizajes activos. Para el desarrollo de las aplicaciones se revisaron los requerimientos generales del juego, los conceptos matemáticos que se abordarían, la realización de las aplicaciones y las pruebas e implementación con estudiantes de ingeniería. Los resultados de la implementación muestran que las aplicaciones fueron funcionales para los estudiantes, sin embargo, tienen algunas oportunidades de mejora, principalmente en la interfaz a fin de que tenga una mayor interactividad.

Aplicación móvil, Matemáticas, Aprendizaje activo

Citation: BECERRA-CHÁVEZ, Adela, HERNANDÉZ-HERNÁNDEZ, Fabiola, ORTIZ-MOCTEZUMA, Enriqueta and MEDINA-CASTILLO, Madeleine. Development of mobile apps for use in mathematics. Journal of Technological Engineering. 2023. 7-19: 1-8

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Introduction

There is currently a diversity of forms and strategies for formal and strategies for formal and informal learning, either face-to-face or online. For online modalities, better known as e-learning, there has been a significant growth of tools and strategies, thanks to the use of ICTs, but also face-to-face learning has benefited from ICTs and learning modalities such as blended learning or b-learning have been generated, which has adopted the best strategies of the face-to-face and online modalities (Hidalgo, *et al*. 2015).

From online learning or e-learning, other models have emerged such as m-learning, which is learning through mobile devices conceived as: access to training programs from mobile devices and without having to use a cable to connect to the Internet (Hidalgo, *et al*. 2015).

The fact that people are increasingly using this type of learning is largely due to the number of users who use their mobile devices, only in 2013 was the year that, for the first time in history, the number of connected mobile devices, mostly cell phones, exceeded the number of inhabitants of the planet (UNESCO, 2013). This trend generates changes in the population both social and cultural, therefore, it is important to understand that this new cyberculture, understood as the set of techniques, practices, attitudes, models of thought and values that develop together in the growth of cyberspace (Lévy, 2007.), requires the development of techniques and strategies that favor their learning. Gamification applied in mobile devices can be an alternative that contributes to improve learning in some areas, as long as it is considered how human beings learn, the skills involved in the learning task and what strategies favor the process of acquiring new knowledge (Rodríguez and Juárez, 2017).

In this paper, 3 applications developed for cell phones are shown with the purpose of contributing to the learning of some mathematics topics that are addressed at a higher level. In addition, the results obtained when testing them with 1st year engineering students at the Polytechnic University of Queretaro are shared, finding areas for improvement, but also, it was possible to identify the usefulness and motivation that it caused in some students.

The development of these applications can be based on the methodology proposed by Rodriguez and Juarez (2017), for the design of m-learning application.

Problem Statement

Martínez and Farfán (2018) define mathematical thinking as the way people who mathematical thinking as the way in which people who are professionally engaged in mathematics think. In this sense, the development of mathematical thinking in students consists of developing their ability to produce explanations and written or verbal procedures through mathematical reasoning to provide solutions to mathematical tasks. In the university, one of the most common problems for students is precisely this ability to produce that mathematical reasoning in the area of study of mathematics that it is, this problem produces other problems such as difficulty in understanding later learning topics, this problem can be supported by the fact that in future practices where this knowledge is necessary, the student is not able to understand or solve correctly, as a result the accumulation of these problems.

Therefore, the teaching of mathematics needs the inclusion of innovative and active strategies that motivate students' interest in new knowledge, which requires the teacher to be flexible in the use of didactic means that help the achievement of learning objectives (Palomino, 2022). Hence the need to implement strategies that contribute to this problem and thus reduce the results derived from this situation.

Objective

To develop mobile applications focused on the mathematical field, allowing users to play and learn at the same time about topics covered at the university.

Methodology to be developed

For the development of the applications, the following stages were the following steps were followed:

Game requirements.

At first, it was reviewed what should be the main characteristics of the application, being described as follows:

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– Be an application for mobile devices such as cell phones or tablets.

– Be an application that involves game play and not an exam or a simple quiz. It can have two game modes: the first individually (one player) and the second in pairs (two players).

– The mathematical concepts addressed in each game must be part of a mathematics curriculum subject offered at the institution.

Choice of the game and mathematical concepts

Before designing the application, the contents of the mathematics subjects taught in the seven educational programs offered by the institution were reviewed, which are: linear algebra, differential and integral calculus, probability and statistics, differential equations and multivariate calculus. It was observed that the subject of differential calculus is the one that has a high failure rate of approximately 40% in the last period that the subject was taught at the Polytechnic University of Queretaro. Because of the above, the subject of differential and integral calculus was chosen with the following fundamental topics that require reinforcement with the students:

– In functions the concept of domain and range.
– In functions, the concept of operations between functions.
– In differential calculus, derivatives.

Already having the concepts to work on, 3 sets were chosen for the applications. 3 games for the applications, which were:

– False or true (challenging your partner).
– Hangman
– Roulette

Application development

For the development of the applications we used:

– Android Studio programming languages, with AlertDialog and LayoutInflater elements.

Mobile application design languages in Java and XML

– Object manipulation tools (OOP) for certain application functions.

– Digital design tools for the development of the different visual elements that were used for the project design (Medibang).

Features of each game

1. False or true (challenging your partner)

The first game that was designed was false or true, where cards are shown and you have to decide whether the information on the card is true or false. Figure 1 shows the main layout of the screen.

Figure 1 Initial design of the main window.
Own Creation

The characteristics of this first set are:

– The mathematical concept is of functions, where the concept of domain and range of a function is reinforced. The domain of a function expressed algebraically, verbally, numerically or graphically will be identified.

– It has two game modes: it can be played individually or in pairs.

– It has a section where the indications and rules of the game are shown.

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– It has a section where the mathematical concepts that will be addressed in the game are explained, as a support for the student.

– It has a record for each game played. During the development of the game, the counter shows how many correct answers are accumulated until the end of the game. In the case of two players, two counters will be enabled, one for each player. Figure 2 shows how the screen is displayed for one player and for two players.

– In each game, there are 16 cards to be checked. Figure 3 shows an example of the game cards.

– Each time a card has been checked, it is disabled from being checked again.

– The game ends when all the cards have been checked.

– The student can play at any time since the game has many cards in its database and each time he/she starts a game, the 16 cards appear randomly.

– Once the game is installed, no internet connection is required to play the game.

Figure 2 Game mode. On the left, single-player game mode. On the right two-player game mode.
Own Creation

Figure 3. Example of a game card
Own Creation

2. The hanged man

The second game that was designed was The hanged man, where the student is presented with two functions and the operation they have to perform between them and write the answer, and if they make a mistake, the image of the hanged man appears. Figure 4 shows the main design of the game.

Figure 4 Initial game design
Own Creation

The characteristics of this first game are:

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- The mathematical concept addressed is that of functions, where the concept of operations between functions is reinforced: addition, product, division and composition of functions.
- The game so far only uses algebraic functions, they are not considered transcendental.
- It has only one game mode, which is individual.
- It has a section where the indications and rules of the game are shown.
- It has a section where the mathematical concepts that will be addressed in the game are explained, as a support for the student, as shown in Figure 5.
- In the game, a keyboard with numbers and mathematical operators is displayed on the screen so that the student can construct the answer, as can be seen in Figure 6.
- The student can play at any time since the game has many functions and different operations to perform, and each time he/she starts a new game, a different one is randomly selected.
- Once the game is installed, no internet connection is required to play it.

Figure 5 Game explanation window
Own Creation

Figure 6 Display of the keyboard for the game
Own Creation

3. Roulette game

The third game that was designed was a roulette, El ahorcado, where the student is introduced to the concept of derivatives. The game follows the logic of roulette, in which the roulette wheel is spun and when an option is chosen, a derivative exercise is displayed and the correct answer must be chosen. Figure 7 shows the main window of the game on the screen.

Figure 7 Main roulette game screen
Own Creation

The characteristics of this first game are:

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– The mathematical concept that is addressed is derivatives, where it is reinforced to calculate and correctly identify the derivative of a function, approaching from basic derivatives, product rule, quotient rule and chain rule, both of algebraic and transcendental functions.

– It has only one game mode individually.

– After spinning the roulette wheel, a window with the derivative to be identified is displayed, as shown in Figure 8.

– It has warning messages when answering a question right or wrong, these would only be pop-up windows that when selecting an answer will not open another window, but within the same window where the question is, there would only be a message with two buttons which will allow you to stay in the question if you had a mistake or return to the window with the roulette to continue with the other questions. See Figure 9.

– The student can play at any time since the game has many functions and different derivatives, as well as different degrees of difficulty and every time he starts a new game, it appears randomly.

– Once the game is installed, no internet connection is required to play the game.

Figure 8 An example of drift types in the game
Own Creation

Figure 9 Message windows, correct or not correct answer
Own Creation

Testing and implementation: results are tested and corrected.

The third stage focuses mainly on testing the application on different devices to verify that it will work correctly in each of them, also proceeded to verify that the tools used for the design perform correctly for use in the devices, This stage of verification of the application for subsequent implementation in the application, also tested if errors or bugs are found within the same application that may hinder its use in the future.

Implementation with students

Mechatronics Engineering and Computer Systems Engineering students were asked to install the applications on their mobile devices and play with them. Subsequently, they were asked to answer a survey that focuses on 3 points: ease of use; usefulness of the concepts and number of reagents shown to practice the topics; and motivation to continue using it. This survey was multiple choice on a scale of 1 to 5, where 1 was strongly disagree and 5 was strongly agree.

At the end of the survey, there was an open-ended question so that students could make any comments or suggestions for improvement. With all this, the following results could be obtained.

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Results

As to whether they found the application easy to install and use, 20% of the students to install and use, 20% of the respondents mentioned that they disagreed or strongly disagreed, while 66% indicated that they agreed or strongly agreed and 14% neither agreed nor disagreed. In addition, 76% agreed or strongly agreed that the application provided enough information to be able to play it. This reflects that in a first version of the applications there is an adequate functionality, however, it is aware that the interface should be further mproved, having an installation guide and help information for the easy use of it.

In the questions referring to the usefulness and quantity of the items to practice and understand the topics, the results were satisfactory, with 82% agreeing or strongly agreeing that the information on mathematical concepts was useful, and 76% mentioned that it helped them to reinforce the knowledge acquired in class.

As to whether the application motivated them to study some mathematical concepts, 72% mentioned agreeing or strongly agreeing. For more details on the questions, Table 1 shows the general survey items and the percentage of students who agreed or strongly agreed with the question.

Question	Answer: agree or strongly agree
Did you find it easy to install and use?	66%
Did you have enough information to be able to play?	76%
Did you have supporting information on useful mathematical concepts?	82%
Did it help you to reinforce knowledge acquired in class?	76%
Did it motivate you to study mathematical concepts?	72%
Did it help you develop logical reasoning?	74%
Has it allowed you to personalize your learning level?	64%
Did it include exercises with a very high degree of difficulty?	48%
Did it help you gain new knowledge?	68%
Did it support you in strengthening your self-confidence?	64%
Did it help you research concepts on your own?	62%

Table 1 Percentage of respondents who agreed or strongly agreed with each question
Own Creation

These results are without distinction of which of the 3 applications they used or if they used all of them, for the particular case of those who only installed one of them, it could be observed that those who only installed the False or True (challenging your partner) 81% of them used it to reinforce topics seen in class, while those who only installed Hangman was 69%. It is not possible to quantify Roulette with certainty, since only 1 student installed this application.

Finally, the results that are considered very valuable for the improvement of the applications are the comments left at the end of the survey, of which we can highlight some that have to do with visualization, such as: improving the typography, improving the interface, aesthetics, etc. While other comments were more in the motivational sense, putting comments such as that they liked the applications or that they found them interesting and fun.

Acknowledgment

We thank the Polytechnic University for the support given to the researchers for the development of the application, as well as to the students who installed the applications in their cell phones and played with them. support provided to the researchers for the development of the application, as well as to the students who installed the applications on their cell phones and played with them.

Funding

The present work has not received funding from any institution.

Conclusions

With the results obtained, in the implementation of the implementation of them, improvements should be made in certain aspects, such as the visual part and interactivity. However, the 3 applications were functional and the objective of developing them in such a way that the students were curious to use the application, that it was easy to understand and that it was available for any current cell phone model, as well as offering a tool that allows the students to reinforce the knowledge they are acquiring, was achieved.

In future works we will be working on comments that users made and were repetitive.

ISSN 2523-6776

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ISSN 2523-6776