Electric Circuit Simulator Applying Augmented Reality and Gamification

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Abstract. In Ecuador, the statistics presented by Educational Evaluation National Institution EENI register that 22.8% of the students from the Andean region and 18.3% from the coast, had insufficient grades in areas that include the study of science (Physics, Chemistry, and Biology). This study proposes the development of a physics mobile application that applies the methodology of gamification and increased reality to improve creativity, academic performance, the interaction between students and teachers (collaborative learning) and that is motivating and interesting for reinforce students' knowledge during use. For the development of the application, the theme will focus on the study of direct current electrical circuits. The proposed application will be made using the development environment called Scratch, which will allow us to create applications in a simpler and faster way with quite efficient results. On the other hand, the gamification methodology is applied which allows the student to use the application, learn, and reinforce their knowledge continuously. The functionalities that will make up the application will consist of the ease and versatility of building various associations of electrical resistances (series, parallel and mixed), circuits (batteries, variable and fixed resistors, motors, etc.) and the use of other components that allow students to set challenges and problems who will be able to solve them in a defined time. This application greatly encourages collaborative work and allows constant information by applying in-creased reality to electronic components. The application creates a safe and dynamic environment for learning since multiple tests can be carried out, fostering creativity, and developing reinforcement learning. The tests carried out have been satisfactory with students, carrying out a control group (traditional teaching) and a test group (with the use of the proposed application). The expected results include an increase in the motivation towards the study of the subject, an increase in teamwork, and an improvement in the academic performance of the students by 20%, through evaluation using questionnaires.

Keywords: Augmented reality · gamification · electric circuit · simulator.

1 Introduction

The teaching of Physics in the context of science and technology constitutes one of the greatest problems and challenges, which may be due to the limited knowledge of teachers in training, in this sense different methodological alternatives should be proposed, giving it a sociocultural and research character. Teaching and learning science means connecting theory with practice, knowing the connections between phenomena and processes, as well as their historical con-text [1].

The International Association for the Evaluation of Educational Achievement (IAEEA) is an entity made up of 70 members, between research institutions and educational evaluation organizations, which conducts studies and reports aimed at understanding and improving education around the world. In this way, it develops the assessments TIMSS (Trends in International Mathematics and Science Study), which are international in nature and have been carried out every four years since 1995; being a valuable tool to monitor international trends in mathematics and science achievement, as they evaluate students' knowledge in all are-as, including algebra, physics and chemistry.

Based on the results of 2015, carried out on a sample of 7,764 students from 358 educational centers in Spain and 276,641 international students from 10,265 educational centers, through multiple-choice and open-response tests, they concluded that the percentage of students who have a high level of learning in science is 5.2% and a very low level of 5.2%, with the best scores the students from Singapore (36.7%). Also that the percentage of students who say "I don't like studying science" is 12% in Spain and in the average of the countries that belong to the OECD (Organization for Economic Cooperation and Development), as well as 13% In the total of countries that belong to the European Union, Educational Evaluation National Institution.

Cantador [2] says that the insertion of technology in the educational field produces an increase in motivation, a better collaboration between students and the management of emotions as facilitating elements of the teaching and learning process, for which a transition from ICT (Information and Communication Technologies) to LKT (Learning and Knowledge Technologies).

According to UNESCO (2013), both students and teachers progressively use mobile technologies in various contexts and for a wide range of teaching and learning purposes, currently, the presence of cell phones in the classroom has produced divisions among the teaching community, since there are those who pro-mote its prohibition and others visualize it as a pedagogical tool. The results show that 43.9% of students and 19.6% of teachers use it as elements to down-load applications related to games and recreation, which could and should be used to improve student learning in science [3].

The Educational Evaluation National Institution EENI in Ecuador, is a public entity that periodically collects information regarding the academic performance of students, in different areas, including Physics, Chemistry and Biology. In 2018, the results analyzed indicated that 22.8% of the students from the sierra and 18.3% from the coast, obtained insufficient grades in those areas, while 47.2% (sierra) and 51% (coast) of the students achieved an elementary level; In the Physics subject, it is due in large part to the difficulty that students have in representing physical objects and situations that allow them to understand various phenomena [4].

As a possible solution to this problem [5], propose to improve the interaction between the object and the subject, through the graphic and real representation of physical phenomena, using animation, that is, augmented reality. Authors such as Cabero and Barroso [6] point out that augmented reality (AR) promotes the abstraction and understanding of physical concepts that may be complex, by dividing them into simpler stages, thus achieving their under-standing from multiple perspectives.

The present work develops a mobile application in the subject of physics, focused on the subject of electrical circuits, for high school students, through the use of augmented reality and the application of the gamification methodology. This work is presented as a contribution to improve the learning and motivation of students in this experimental science.

2 Methods and materials

The effectiveness of a learning methodology lies in several factors such as the characteristics of the student, the teacher and the subject to be taught, as well as the objectives set.

Gamification

The term gamification is originally used by the British software designer and programmer Nick Pelling in 2002, from the business field and it was until 2010 when it began to be used in the educational field. It is designed to allow the trans-formation of products, social or educational aspects into games with clearly established and delimited objectives [7].

Gamification refers to the use of game mechanics in non-playful environments and applications, as a fundamental tool to improve motivation, concentration and the development of values [8].

Augmented reality

As far as augmented reality is concerned, in 1962 the cinematographer Morton Heiling developed the Sensorama motorcycle simulator, which recreated a ride through the streets of New York, in this regard, the first term coined was virtual reality, which arises in 1965 when Ivan Sutherland publishes the scientific article entitled "A Head-mounted Three-Dimensional Display" and describes the screen as a window through which it is possible to identify a virtual world, allowing it to be seen and perceived as the real world [9].

The beginning of augmented reality (AR), according to Sabarís and Brossy [9] dates back to 1992, where David Mizell and Tom Caudell published their work called “Augmentative reality: an application of heads up display technology to manual manufacturing processes” in response to a variation of virtual reality technology and as an enrichment of the real world, being applied for the first time in the manufacturing industry.

3 Prototype proposal

The learning circuits prototype was developed for the learning of electrical circuits in series, parallel and mixed with high school students and consists of an application that can be used from any device with data, fixed or mobile

The topic of electrical circuits was selected because a large number of students have difficulties in understanding how electric current circulates through bulbs, motors or any other resistive element, for this reason, it is considered important and relevant to motivate fourth year high school students around achieving a better understanding of the subject, in a playful and entertaining way.

To develop the prototype, augmented reality was used, that is, beside of simulating an electrical circuit with its corresponding connotations of voltage, intensity and resistance, sound or visual signals are supplied, as indicators that the connection to be made is not secure, it is not correct or that may involve some type of risk, as it happens in a short circuit, high voltage or an overheating of any electrical element.

There are countless limitations for young people to carry out this kind of experimentation in real laboratories, among them are the fact that several educational institutions do not have the economic resources to implement them, and there are also those who show fear that, for a bad connection, a thermal effect is generated that can burn them, or an electric shock that faces some type of risk.

When analyzing the range of technological tools for the development of the application, the programmatic environment of "Scratch" was chosen, as it allows to carry out block programming, in a synthetic, versatile, easily understood and adaptable way for all users, this from a playful perspective, with a gamified teaching-learning system.

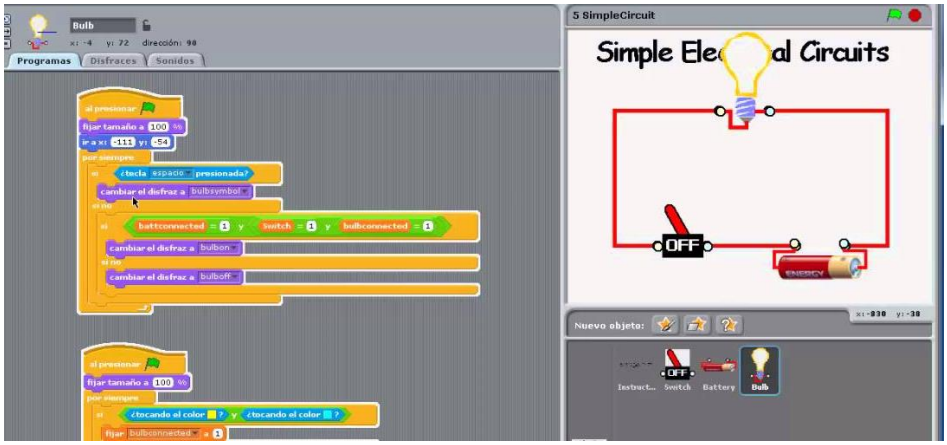

Fig. 1. Scratch block programmatic environment, with application to the diagramming of electrical circuits

Figure 1 shows part of the Scratch programming environment, which makes it easier for an early age student, becomes familiar with block programming and to follow simple instructions to modify it, incorporating game parameters to their liking.

The actions undertaken around developing the circuit prototype included defining the type and quantity of electrical devices that could be included, such as bulbs, batteries, resistors, switches, etc. Later establish if the connection that is required to represent is series, parallel or a combination of both, which is known as mixed.

The next step consisted of drawing the objects to represent and how they will interact, in addition to including the necessary cables and switches, after which the blocks, sentences and appropriate coordinates were chosen for the circuit to work under the Scratch programming logic and with the fundamentals of physics regarding the circulation of electrical charge (current) along conductors and other electrical elements.

In the programming dynamics, it is essential to declare the variables and their conditions within the chosen scenario, which is done considering the number of switches present, assigning them a name or symbol and setting their position at 45 o 90 degrees, depending on whether they are open or closed respectively; It should be noted that the switches will allow or prevent the normal circulation of electric charge through one or more parts of the circuit, as the case warrants.

On the other hand, it is necessary to program the operation for the rest of the electrical elements such as lights, LEDs and motors, declaring the conditions in which they should be turned on or off (ON / OFF) in a coordinated and synchro-nous way with the positions open or closed of the switches that are part of the circuit. It is also essential to foresee all the possible combinations that can be made, in such a way as not to incur errors that violate fundamental physical principles, such as the conservation of charge or energy.

In the same sense, messages with their respective associated sound signal were included, which identify them as informative, control, motivational, instructional or safety and that synergistically correspond to alerts on, off, danger, poorly con-nected, you did excellent, you are on the right track and others like those.

Among the functionalities that the application presents, it is included that the student becomes familiar with the two possibilities of presentation of electrical circuits, one provided with the symbology of the constituent devices such as sources, lights, motors, resistors, switches, breakers, conductors and the other in pictorial form with real images incorporated of those elements, all of this in order to effectively and pertinently strengthen the learning of the proposed topic. Logically, the formation of series, parallel or mixed arrangements with these elements is allowed.

The results that are intended to be achieved with the mentioned application include an improvement in the learning of circuits and the capacity for logical-deductive reasoning, in a playful and entertaining way, in addition to awakening motivation and creativity in the student with the proposed topic, which without doubt will undoubtedly lead to a significant advance in a holistic way, in the physical understanding of the phenomenon studied and therefore in the academic performance of the subject, which has been established at 20%, measured through evaluation with various questionnaires.

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