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# Didactic device for early learning stimulation in children from 3 to 5 years of age

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***Abstract*---**The objective of this project is to design an electronic device to stimulate learning in children from 3 to 5 years old through interaction and play. The methodology applied was carried out in several steps, the first of which was the consultation of literature on early stimulation, learning, and preschool teaching methods. Next, the hardware and software tools to be used for the development of the device were selected. Then, the construction of the box was carried out with a design that would attract the children's attention. To later assemble with the electronic circuit, which will be integrated by a NodeMCU ESP32 and RFID readers for reading the UID of the cards, this circuit will be programmed to carry out the purpose of the device. Finally, a mobile application was designed and programmed in Android Studio to display the activities to be developed. It should also be added that the connection between the application and the didactic

box will be via Bluetooth. The functionality of the didactic device was revealed through a survey of the children's tutors after they interacted with and manipulated the device, which resulted in the fulfillment of the hypothesis set out for this project.

***Keywords*---**didactic device, stimulation of learning, RFID, children.

## Introduction

One of the goals in preschool education is to achieve different social and academic skills, such as colors, vowels, numbers, etc., which in some children may show difficulties. Because different factors affect learning at this age (3 - 5 years) as some disability, distraction, school stress, frustration, lack of interest, personal motivation, and even the lack of preparation and training of some educators, etc. According to UNICEF (United Nations International Children's Emergency Fund), the first 5 years of life lay the foundation for children's cognitive, emotional and social development. Learning in children from 3 to 5 years old is feasible when there is stimulation with objects that they can manipulate to their liking in a safe environment and thus learn and explore the world around them.

Nowadays, the use of new information and communication technologies makes it possible to carry out different projects that involve different development and study topics, one of these oriented to education and learning. This allows for the application of it in conjunction with playful learning techniques and stimulation of children so that they can improve their learning, such as vowels, alphabet, numbers, colors, figures, and so on. The focus of this project is the development of a didactic device in which children can develop dynamically and playfully different skills in their early school years. This didactic box introduces basic topics such as colors, the letters of the alphabet, and numerical quantities. The didactic device consists of RFID cards with which children must interact to give answers, in addition to the use of Bluetooth connectivity with which a mobile application will be connected for the use of the teacher, parent, or the person who is guiding the child in their learning.

## Related work

The Journal of Speech Therapy, Phoniatrics, and Audiology, 2019 presents an article entitled "Experience of application of a language stimulation program carried out in inclusive kindergarten classrooms" (Cuevas *et al.*, 2019). The objective of this research is to analyze the results of applying an oral language stimulation program, applied to a kindergarten classroom, in which a collaborative-inclusive intervention model was applied. Twenty-eight children participated in this program and their skills were evaluated before and after applying for the program. The journal of Logopedia, Phoniatrics and Audiology, in 2014 presents an article developed by Montserrat Durán, Ana López, Juan Fernández, Manuel García and Sandra García, study with the theme "Pilot study on the implementation of a ludic program in the school context for language stimulation" (Durán Bouza *et al.*, 2014). Designing and applying to 25 third-year students a ludic-educational program to stimulate the language of children with

and without specific difficulties. This program tries to answer the need for tools in the classroom, which act on the difficulties that arise during the development of children's language.

In June 2019 in the Journal of Psychodidactics, there is the title "Virtual intervention program to improve working memory and basic math skills in Early Childhood Education" (Fernandez et al., 2019). This paper aims the design and implementation of a virtual education intervention program, based on learning through gesture play, to help working memory and basic math skills. In 2014, the magazine Perfiles Educativos published a paper entitled "Information and communication technologies for educational innovation" (Ruiz & Ortega, 2014). This work brings together ten new proposals on education in different scenarios and a field of study in which the concerns of the environment of science concerning information and communication technologies (ICT) and their application in education are brought together. In the magazine Suma De Negocios in 2017, there is a research degree work entitled " Influence of Smartphones on learning and teaching processes" (Silva & Martínez, 2017). The study seeks to know what influence has the Smartphone on the design and dynamics of pedagogical strategies in learning. As a consequence of the study of previous works, an analysis of the advantages and disadvantages of the learning processes was carried out.

In conclusion, these studies are focused on analyzing different aspects of education and tools to help improve learning stimulation in different branches, for different needs and special abilities. The difference of this project proposal is that it is focused on children from 3 to 5 years old, using a didactic box and technology that stimulates the visual, auditory, and motor areas of the child, in addition, the tutor or teacher has an application in which he/she can visualize what activity is going to be performed and know if the child's answer is correct, besides guiding the child in the activity. Finally, in terms of similarities, these projects are focused on children who need help with learning using playful and technological processes.

## Materials and Methods

### Methodology

For the development of the project, 5 stages are considered, as follows:

- Stage 1: Compilation of early stimulation methods and preschool teaching methods.
- Stage 2: Design of the embedded system of the electronic device.
- Stage 3: Development of the code of the didactic box.
- Stage 4: Design and development of the mobile application.
- Stage 5: Functional testing of the didactic device.

### Materials

Among the different resources used in the construction of the didactic box is the NodeMCU Esp32, a module that allows the connection of RFID readers for reading

RFID cards. In addition, the NodeMCU Esp32 is equipped with Bluetooth technology used for connection to the mobile application. The programming of the ESP32 development board module that makes up the didactic box, was developed through coding in C++ language, through the Arduino IDE. Also, the design and programming of the mobile application are based on Java language developed with Android Studio software. The following is a summary of the materials used:

Table 1
Didactic Box Hardware Resources

| | |
|---|---|
| NODEMCU ESP32 | Open-source development board, built with the ESP-WROOM-32 chip. With Bluetooth and Wi-Fi communication.[a] |
| Readers RFID RC522 | This reader has a maximum reading range of 5 cm and operates at a reading frequency of 13.56 MHz.[b] |
| Cards RFID RC522 | The card contains an RFID chip and antenna and is passively powered by the reader/writer when approached.[b] |

*Note*. [a]Carmenate (2021). [b]Del Valle Hernández (2020)

As shown in "Table 1", hardware resources were chosen that are accessible, low cost, and also that their management and programming do not generate greater complexity. The NodeMCU ESP32 was chosen as the development board because of its accessibility, easy handling, low cost, and the variety of communication media available, such as Bluetooth and Wi-Fi. In addition, the RFID reader chosen for the development of the system is the RFID RC522 because it is accessible and easy to program, as well as RFID cards.

Table 2
Software resources used for device development

| | |
|---|---|
| Arduino IDE | Environment that allows the programming of the Arduino board and the ESP32 NodeMCU board.[c] |
| Android Studio | Official programming environment for the development of Android applications.[d] |

*Note*. [c]Arduino (n.d.); [d]Developers (n.d.).

In terms of software resources for easy use in programming, we resorted to easily accessible and official programs. For the embedded system we used the Arduino IDE and for the mobile application Android Studio, the official environment for developing mobile applications on Android.

Table 3
Programming languages used for project development

| | |
|---|---|
| C++ | Programming language extension of the C language. It was used for the development of the didactic box.[e] |
| Java | Object-oriented programming language derived from the C language. It was used to develop the mobile App.[f] |

Note. eAronowitz (2021); fBohada et al., (2019)

The programming part, we resorted to languages already known and easy to use in programming as can be seen in "Table 3". C++ is the language used in the Arduino IDE. On the other hand, the mobile App is developed in the Java programming language.

**Development**
**Stage 1**

To determine the design and the ludic activities to be carried out in the didactic box, bibliographic consultations were made on the types of early stimulation methods and preschool teaching methods. After the bibliographic review, a 5-question questionnaire was sent to 10 parents who have children of the ages included in the project. This previous questionnaire served to know the perspective of the parents about the integration of a complementary method for the education of their children in a didactic way, among other questions of interest for the project. These questions and the answers obtained are shown in Table 4, where they are rated from 1 to 5, with "strongly disagree", "disagree", "slightly agree", "agree" and "strongly agree", respectively.

Table 4
Pre-survey results

| Question | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Do you think it is necessary to implement another type of method for an interactive and dynamic education for children from 3 to 5 years old? | - | - | 1 | 4 | 5 |
| Do you agree that it is a good alternative to apply games and technologies in education? | - | - | - | 4 | 6 |
| Do you think it is a good alternative to implement a didactic and technological device with which children can play for their school development? | - | - | - | 2 | 8 |
| Do you think a tutor must keep track of the child's activities through a mobile application? | - | - | 1 | 2 | 7 |

| | | | | | |
|---|---|---|---|---|---|
| | Numbers | Alphabet | Colors | Geometric figures | Environment |
| What topics would you recommend to have in the didactic device? | 4 | 2 | 2 | 1 | 1 |

Note. Adapted by Arboleda et al., 2022

Table 4 shows the answers obtained from the parents of the selected children. In this table, it was asked which themes they would recommend being practiced in the didactic device. There were 3 themes with the most votes (numbers, alphabet, and colors), therefore, based on this data, we proceeded to develop the themes of the didactic device.

**Stage 2**

Continue with the realization of the project we proceeded to design the block diagram of the embedded system architecture of the didactic box (see Figure 1), this system consists of the main board NodeMCU ESP32 to which 3 RFID readers will be connected, responsible for reading the RFID cards that will have a value set by programming. In addition, through this board, the mobile application can be connected to the whole system via Bluetooth.

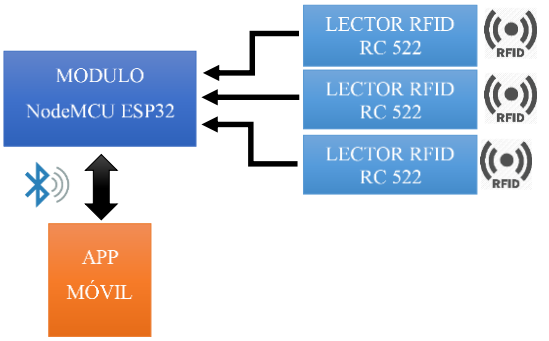


Figure 1. Didactic device block diagram
*Note*. Adapted by Arboleda *et al.* (2022)

**Stage 3**

In this stage, the code for the embedded system in the Arduino IDE, for the management of the RFID readers, and the programming of the RFID cards, as well as the programming of the NodeMCU BlueTooth, were developed. As shown in the flowchart (Figure 2) the functionality of the system is that the readers detect the RFID card, then through code is analyzed if its UID (unique identifier) is correct, if not, this process is repeated, and if it is correct, the process is finished and an alert will appear in the mobile App that it is OK. Then it will proceed to perform another activity.

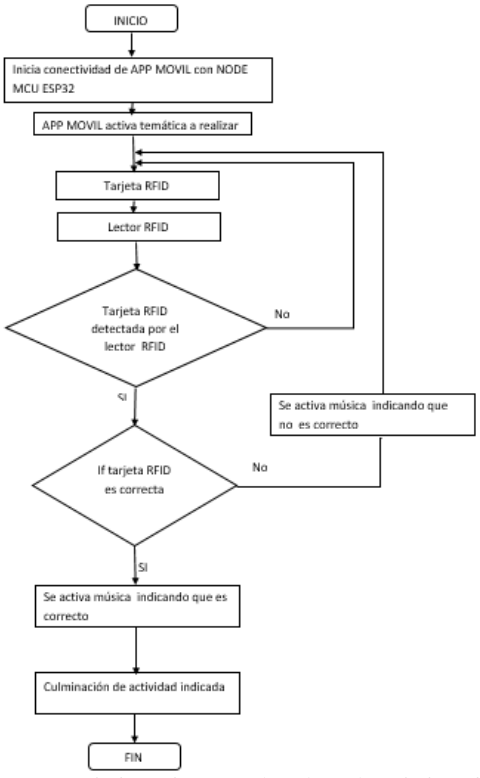


Figure 2. Flow diagram of the electronic circuit of the didactic box
Note. Adapted by Arboleda et al. (2022)

**Stage 4**

The design and development of the mobile application were carried out using Java language, this app makes use of the Bluetooth communication technology of the cell phone to link with the Bluetooth of the NodeMCU. Once connected to the application, it is possible to see what activity the child has to perform and if the answer to this activity is correct or not. In addition, the buttons that this app has are the following:

- **PLAY** allows starting the game. The "Your answer" section shows whether the cards entered by the child are correct or incorrect.
- **BLUETOOTH ON/BLUETOOTH OFF is** used to activate or deactivate respectively the Bluetooth communication on the cell phone.
- **DISPLAY SYNCHRONIZED DEVICES**, allows for to display of the devices that are visible for establishing a Bluetooth connection.
- **DISCOVER NEW DEVICES,** allows updating the list of devices that are visible or have Bluetooth enabled.

To develop the application, first, a graphical interface was created to proceed with the main activity, which contains the main program of the application. Then, the necessary libraries were imported to carry out the programming of the

application. Finally, the APK file was generated, which contains the application to be installed on a cell phone and starts with the respective tests.

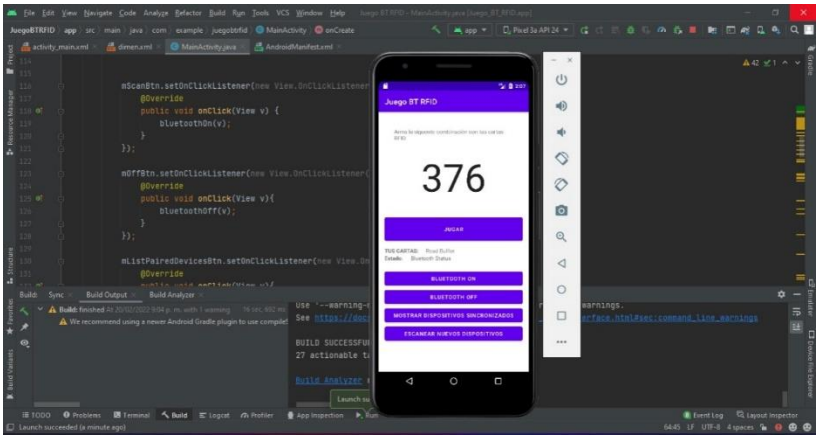


Figure 3. Mobile application development
Note. Adapted by Arboleda et al. (2022)

**Stage 5**

Once the didactic device (box + mobile application) was completed, tests were conducted with 10 children who met the age established for this project (3-5 years old) under the observation and guidance of their respective parents. At the end of the interaction with the device, the parents were asked a questionnaire, this survey consisted of 5 questions related to the use of the device and their impressions about it. The questions of this survey and the respective answers obtained are shown in Table 5, where the answers are valued from 1 to 5, with "strongly disagree", "disagree", "slightly agree", "agree" and "strongly agree", respectively.

Table 5
Results of the survey on the acceptability of the didactic device

| QUESTION | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Do you think the device is easy to use? | - | - | 3 | 6 | 1 |
| 2. Do you think that the learning device and the mobile application achieve the objective of stimulating children's learning? | - | - | 3 | 5 | 2 |
| 3. Do you think that the different functions of the device and the application are well integrated? | - | - | 3 | - | 7 |
| 4. Do you think that the child can grasp the dynamics of each game without the help of an adult? | - | 1 | 4 | - | 5 |
| 5. Would you recommend this device to someone else? | - | 2 | 5 | - | 3 |

*Note.* Adapted by Arboleda *et al.* (2022).

## Results and Discussion

According to the results obtained in the second survey (Table 5), the second is directly related to the hypothesis of our project, in which 30% of the respondents indicated that they "slightly agree" that this didactic device allows for improving skills and abilities to interact in the children's learning environment. However, 70% indicated that they "agree" or "strongly agree" that this device allows improving skills and abilities to interact in the environment. Taking into account these results, there is a majority of compliance with the stated hypothesis. Without leaving aside the 30% giving an answer between negative and positive, which indicates that certain technical aspects, as well as the implementation of the device, should be improved, be able to fulfill the initial hypothesis with 100%. Regarding the other questions, 70% of the parents indicated that they strongly agreed that the different functions of the device and the mobile application are well integrated. In addition, 70% also indicated that they agree and strongly agree that the device is easy to use. Finally, the answers with the most "negative" responses were the fourth one, which asked if the child could grasp the dynamics without the help of an adult, and half of them answered that they "disagreed very little", which is somewhat evident since these are very young children. While on the last question, 50% of the respondents indicated that they "somewhat agreed" to recommend the device, and 30% "strongly agreed" to do so.

## Conclusions

The didactic device stimulated learning in most of the children through the themes of numbers, alphabet, and colors. Through a survey conducted with the children's tutors, the most suitable themes and activities to be included in the device were determined. The necessary low-cost hardware components and free software were defined for the development and elaboration of the early stimulation device. A mobile application was developed in Android Studio software capable of displaying a friendly user interface for interaction by the tutor. This application was necessary for the tutor to supervise the activities to be performed by the child.

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