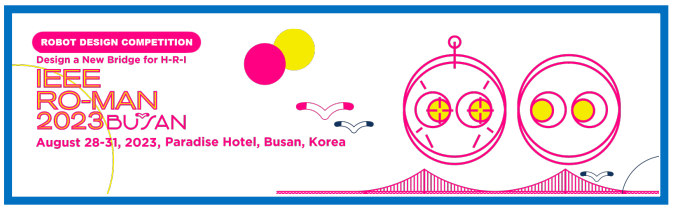
Yachabot: Interactive Blocks for Learning Math



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The incorporation of technological educational resources in primary schools is crucial for exploring new teaching methodologies. Additionally, this allows for the improvement of the current educational system to effectively meet the needs of students. Yachabot is an interactive robotic object based on a system of interactive blocks designed to level and reinforce mathematical concepts for fourth-grade primary school students. Yachabot consists of three learning blocks aligned with the curriculum followed throughout the school year, with each block covering a different topic: units of measurement, numerical operations, and geometric analysis. Each block is used according to the specific topic being taught, connected to a main block that features a screen and three buttons serving as controllers. Through this system, users can develop cognitive skills in this field while having fun.

INTRODUCTION

In Peru, the COVID-19 pandemic had a significant impact on the education system. Many students from different parts of the country faced difficulties in accessing online classes due to the lack of technological resources and proper internet connectivity. In response to this, the Peruvian government launched the "Learn at Home" program on television and radio to broadcast classes for students. However, 9% of students were unable to utilize it due to a lack of power supply in some areas of the country [1]. As a result, the learning capacity of students was also affected by the fact that siblings and parents had to share devices; consequently, some children had to review previous material to catch up.

Furthermore, as a government decision during and after a year of the pandemic all students were promoted to the next grade without considering whether they achieved the required competencies, which made them reluctant to access content from previous grades. Consequently, considering the group of years with the highest difference, fourth-grade students in public schools showed a substantial 10.7% decrease in adequate knowledge of mathematics compared to 2019, according to the national sample assessment conducted by the Ministry of Education of Peru [2].

RELATED WORK

An interesting example of an interactive teaching tool made to improve creativity and learn Korean characters is HangulBot. It achieves this by leveraging modular building blocks, which provide a fun and active method of language learning [3]. Similar to this, we find, Hermites offers an alternative strategy via an interactive device that uses modular blocks with wheels and is modeled after hermit crabs [4].

Another noticeable example of a teaching tool that engages kids by making learning into a game is the Sony Toio. The Toio kit was created with the express purpose of exposing children to the world of programming while letting them explore their creativity [5]. Students can

build miniature toys through programming that they can later interact with and control.

We also have Osmo Education, which is a learning environment that made interactive by combining an iPad with numerous tangible pieces. The iPad scans these items, which are then digitally included in the display. Students can participate in tasks like working on math problems or painting on a digital whiteboard, and their work will be included in the interactive game that helps them learn [6].

These works exemplify the interactive nature of educational technologies and their ability to engage children in learning through play, creativity, and hands-on activities. Drawing inspiration from the dynamics of these studies, we propose an approach that not only embraces interactivity but also enhances children's mathematical education while they engage in play.

DESIGN PROCESS

We designed the objects based on the learning capabilities which students need to reinforce according to the national curriculum established for each grade. Considering this document, we decided to develop a modular object that could be used for different activities. As a result, a key factor we took into consideration in the design was that the block had to be easily adapted to various learning tasks.

At first, we had the idea to make different blocks that could interact with each other, but then we realized that having just one main block would be better as it would be easier to use. The main block has different accessories with objects on each according to the topics covered. The mathematical skills we decided to focus on are geometry and arithmetic as they are the foundation for more advanced mathematics and a tool that will help them to solve problems of everyday life.

On the other hand, the meaning of the name Yachabot comes from the word Yacha, which means “to learn” in Quechua, one of the most spoken languages in the Peruvian Andes.

The realization of the visual design of our prototype consisted of several stages that allowed us to have a better perspective on each new model until we reached the final design, which can also be seen graphically this process in Figure 1.

Before starting with the first design, we carried out a brainstorming process in order to know the perspective that each member of the group had about the project. This way, we were able to reach a consensus as a team and form the basis of its operation.

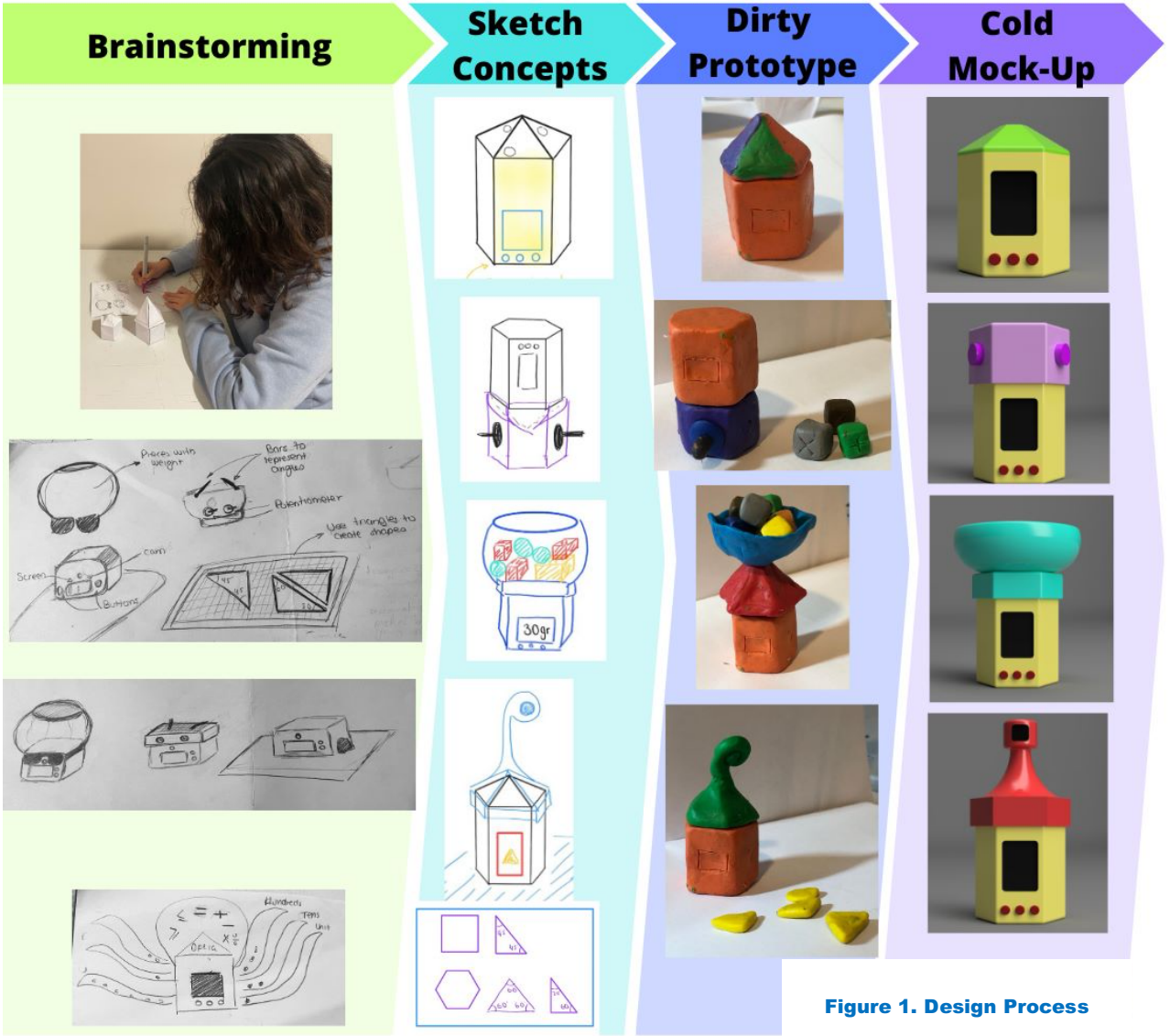

Figure 1. Design Process

Sketch Concepts: Hand sketches of the main module and accessory blocks were made. In these, we saw in detail the shape of the project, the objects that each of the blocks would present, and how our robot would work in each drawn part.

Dirty Prototype: Assembly that was made quickly with easily available materials. For our prototype, we used plasticine and it allowed us to have a concrete and tangible representation of our design. In addition, it would allow us to analyze how the interaction between the human and the robot would be as it is a design that can already be manipulated.

Cold Mock-up: The dimensions of each of the parts and the location of the electronic components used in them were established by 3D modeling. In this part, we analyzed possible design errors that could have been found, for example, for the fittings, the mechanism, and the space between components. Likewise, we consider the tolerances present in its dimensions so that it can be assembled correctly.

Technical prototype: We established the use of the electronic components used in each block and how they act in the design. The hexagonal-shaped top allows Yachabot to be coupled with each of the blocks for the topic to be taught. In addition, it has a 7-inch screen where the activities will be displayed, three buttons that act as controls, an RFID module that, with an Identity Key recognizes an operation like addition or subtraction, and the microcontroller. The block for learning measurements has a load cell that supports up to 5kg, the measured weight data is sent directly to the microcontroller and displayed on the screen. The number learning block has two potentiometers that, by changing their resistance value when turned, allow changing the values of two numbers displayed on the screen. Finally, the recognition learning block has a camera that recognizes quantities and shapes, so that the user can create different shapes that will be recognized by the camera and displayed on the screen.

INTERACTION DESIGN

The prototype is designed for kids who are in school, between the ages of 9 and 11. Using interactive cubes, this robot reinforces math at a level suitable for the user's age while teaching a variety of topics depending on the current curriculum of learning in schools. It was designed to be visually appealing and engaging for the user in order to motivate learning and do so more effectively. The context of use is in the classroom or at home as Yachabot is intended to aid children in situations where learning difficulties are present.

Figure 2. Children using Yachabot

Children should be familiar with operations, relationships, and numbers. They should have a general concept of adding and subtracting heterogeneous fractions as well as combining operations with natural numbers[7]. This need is met by a block in Yachabot that has knobs for users to input natural numbers or fractions. The RFID cubes can be used for simple operations. The procedure is visible on the main block's screen. Children can practice and improve their ability to execute operations with numbers and fractions with Yachabot, which offers an engaging and practical method to do it.

The National Peruvian Curriculum for Regular Basic Education states that children between the ages of 9-11 must develop geometry skills, especially in concepts like sides, vertices, and angles of geometric bodies [7]. A lesson block on Yachabot is dedicated to instructing on these topics. The camera on this block enables the kid to work in front of it and recognize the shape built by the user. It does this by identifying the vertex and sides. To build the shape, the user has a set of triangles that can be placed together. It's important to note that the procedure can also work in reverse, allowing a child to watch a figure or be given a statement like “build a 5-point polygon” on the screen and they need to do it. The camera will recognize if they were able to do it. Yachabot offers a helpful tool for interactively and visually reinforcing geometry.

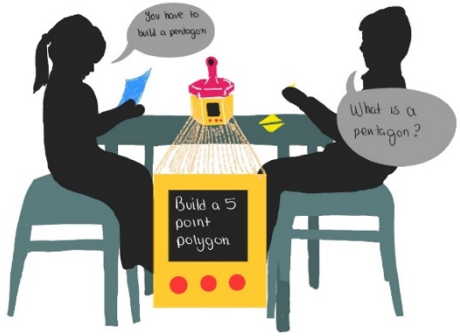

Figure 3. Children learning geometry with Yachabot

Children also need to learn about measurements of mass in relation to their respective units. Students must be able to solve problems that call for this knowledge [7]. This need is met by Yachabot's measurement learning block, which gives users the ability to comprehend ideas about volume and mass capacities. For instance, if a user wishes to learn more about this subject, they can start by setting the measurement block and filling the bowl with things to get a specific measurement with their respective units. The user can change the unit of measurement by pushing the buttons while the measurement is displayed on the screen.

Figure 4. Children using the measurement block

Yachabot uses interactive blocks to improve user experience and encourage learning. Users gain mathematical skills through tactile and visual learning. It has potentiometers for spatial awareness that sequentially change numbers. Using buttons, users can choose alternatives or answers from topic menus. Users can put together geometrical figures and create complex figures. With the help of these features, new three-dimensional figures are produced. Students are engaged by visual interactions on the screen, which support didactic and visual learning. Yachabot provides important advantages for kids' schooling.

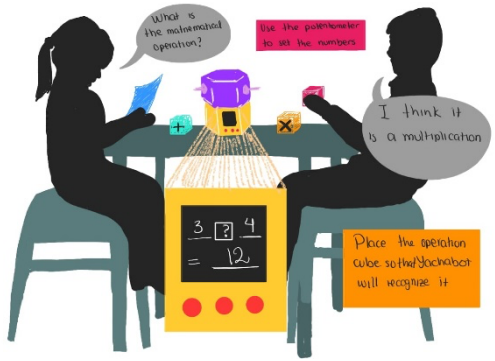

Figure 5. Children practicing mathematical operations

Figure 6. Working Prototype

Figure 6 show the first working prototypes of Yachabot; these were 3D printed in PLA. The one to the left is the main block itself and the one on the right has the mathematical operations add on. As we can see the add on fits directly on top of the main block, as mentioned before this is done to make the add on interchangeable. The add on and the main block have a connector that allows the functionality of the block to work.

The blue blocks in figure 6 are the mathematical operators that the students will use by placing on one side of the main block, which has the RFID reader.

It is important to mention that the interaction with Yachabot can be done in groups as depicted in the different figures but it can also be used by one student at a time.

CONCLUSION

In conclusion, in response to the educational challenges identified due to the COVID-19 pandemic, we have designed an interactive robotic object with add-ons that allow the most affected group of students to develop their mathematical competencies. Yachabot's functions are based on the content and competencies required by fourth-grade primary school students according to the National Curriculum for Regular Basic Education. Yachabot aims to reinforce and level the mathematical skills of its users through interactive tools.

In the future, our objective is to make Yachabot a learning tool that can be utilized in the educational system for all students, according to their current needs. Furthermore, we plan to enhance the user experience and expand the variety of blocks to cover other topics taught within the educational system.

ACKNOWLEDGMENT

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