A LOW-COST ELECTRICAL CIRCUIT PROTOTYPE TO HELP WITH THE HEIMLICH MANEUVER

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ABSTRACT

Choking is one of the main causes of infant mortality, and it is estimated that it is the third cause of death from accidents among children in Brazil. To contribute to the promotion of life, this project aims to develop a low-cost electrical circuit prototype to help with the Heimlich maneuver, which is the first aid procedure used when a person is choking. Besides being accessible to everyone due to its low cost, the promoted prototype allows anyone to perform the Heimlich maneuver, which has the potential to improve the first aid care offered to children in all schools in Brazil and the world.

1. INTRODUCTION

Choking is one of the main causes of infant mortality, especially among children under 5 years old [1]. Most choking-related incidents among children are associated with food, coins, and toys [2]. For those cases where the child is choking, the American Heart Association recommends applying the Heimlich maneuver, a technique that can be used to help expel an object stuck in another person's airway [3]. Although investments in child health promotion health have grown, it is still estimated that it is the third cause of death from accidents among children in Brazil [4].

In 2018, the Lucas Law (13.722/18) was enacted in Brazil [5]. This law obliges schools and children's recreation spaces to be prepared for first aid. This law arose from an accident with a child of only 10 years old, who lost his life on a simple school trip when he choked on a piece of sausage from a hot dog during lunch, since none of the teachers or employees knew how to help him. Even though the law is in effect today, it is not actively enforced. An interview conducted in 2021 at a Brazilian school showed that 57% of the employees had done first-aid training in the last years, and only 40% enrolled in a first-aid course during graduation [6]. This corroborates with Silva *et al.* [7] that report the lack of knowledge in the school environment of teaching professionals in relation to first aid, suggesting that this lack of knowledge leads to probable unforeseen events and injuries to children.

Although Brazil has a law, we do not have guarantees that all schools have prepared their educators with first aid training and that they can protect our children, especially public schools with fewer resources. In this regard, Leite *et al.* [8] presented a study with early childhood education teachers in which 88% said they did not feel safe to provide care in emergency cases.

Therefore, it is mandatory to facilitate access to first aid knowledge to a lay public, since accidents often occur in domestic and school environments, which would help to promote immediate and qualified first aid care to all [9]. In this regard, this project aims to contribute to the protection of children's lives. First, by developing a low-cost electrical circuit prototype that is accessible to all. Second, to help anyone to perform the Heimlich maneuver. These two goals together have the potential to improve the first aid service offered to children in all schools in Brazil and the world.

2. THE HEIMLICH MANEUVER

Choking occurs when an object blocks the airflow by getting stuck in the throat. For such situations, various techniques can be applied to make a person expel it. The most effective of these techniques is known as the Heimlich maneuver, or abdominal thrusts, which is addressed in this project. The maneuver lifts the diaphragm, causing air to be expelled from the lungs, creating enough pressure to expel an object stuck in the

throat. This technique is recommended when a person cannot cough or speak while choking.

Fig. 1 shows how to perform the Heimlich maneuver. First, (1) stand behind the person and place one foot slightly in front of the other for balance. Second, (2) wrap your arms around the waist with your arms underneath their armpits. Make a fist with one hand and position it slightly above the person's navel. Grasp the fist with the other hand. Then, (3) perform quick, forceful inward and upward abdominal thrusts (as if trying to lift the person up) until the object is expelled. The procedure must be repeated until the blockage has been removed.

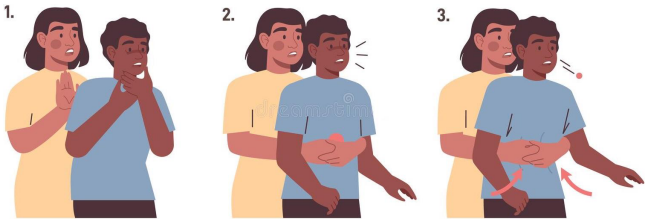


Fig. 1: Heimlich maneuver procedure for removing an object stuck in a person's airways [10].

Note that the Heimlich maneuver is highly effective. However, it is not recommended for use on infants 12 months or younger [11].

3. ELECTRICAL CIRCUIT PROTOTYPE

Our project aims to help people perform the Heimlich maneuver more autonomously, which we hope will assist in applying the Lucas Law in Brazil. In this regard, we have developed a low-cost electrical circuit prototype that will indicate to whoever is going to use it, the force and the place where the Heimlich maneuver must be applied.

Fig. 2 illustrates the electrical components used in the prototype, the main one is an Arduino Nano that will control all the project's logic. Furthermore, we will have a force sensitive resistor (FSR 402), which will manipulate the force applied in the Heimlich maneuver. A speaker outputs the audio: more, less, and OK. Note that for this speaker, we needed an amplifier circuit because its audio is very low. In addition, two external cell phone batteries were used to power the circuit (it couldn't be just one, as they have 4.35V and to power the Arduino, we need at least 5V). And finally, we use an SD card module to store the recorded audio.

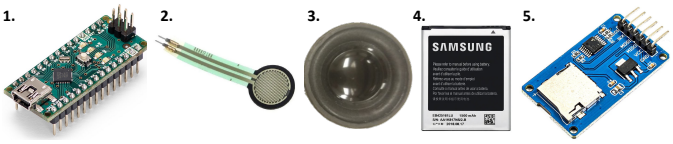


Fig. 2: Illustration of required prototype components.

Table I shows the prices for each component found on Amazon.com, indicating that the prototype had a total cost of $72.00.

TABLE I
COMMERCIAL PRICE OF REQUIRED PROTOTYPE COMPONENTS

Components	Price
Arduino Nano	*$ 25.00*
SD Card Adapter Module	*$ 6.00*
Speaker	*$10.00*
Two Batteries	*$ 12.00 (each)*
Force Sensing Resistor	*$7.00*

In terms of logic, the Arduino Nano features a 10-bit Analog to Digital Converter (ADC), which can detect 1,024 discrete analog levels. So, we focus on the voltage drop caused by the change in resistance when force is applied to the FSR sensor. We observed that the more force applied to the FSR, the less resistance there will be in the sensor, causing the voltage drop to be large and, consequently, the reading of the analog port will be high. Fig. 3 shows the characterization of the prototype, which categorizes the ranges that will detect whether the person should apply "more" force, "less" force, or if the force is correct ("OK") when performing the Heimlich maneuver.

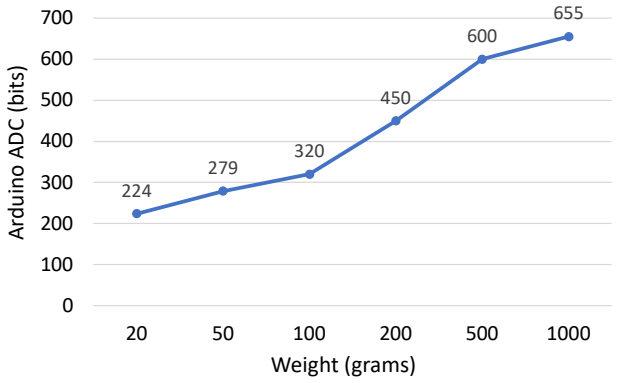
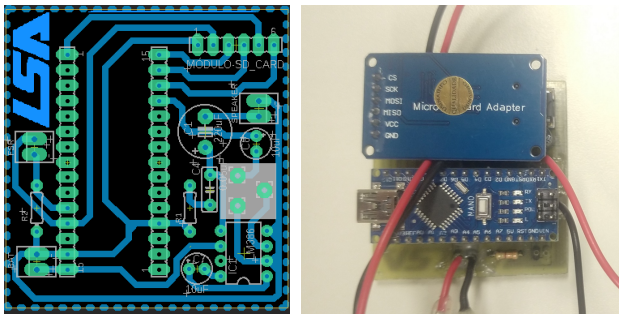


Fig. 3: Prototype characterization.

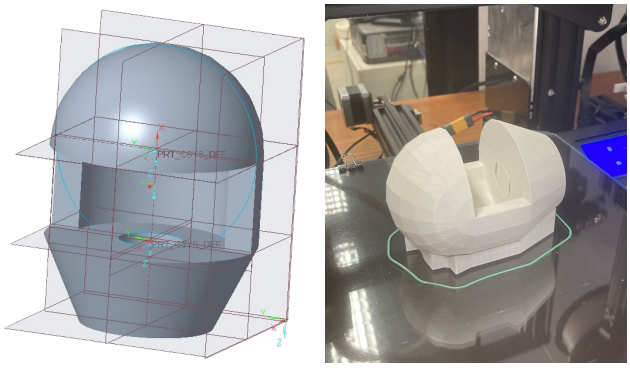
Fig. 4 shows the printed circuit board. As the original speaker audio was too low, we implemented an amplifier circuit (Fig. 4.a) and integrated it with Arduino Nano and SD card module (Fig. 4.b).



(a) (b)

Fig. 4: Printed circuit board.

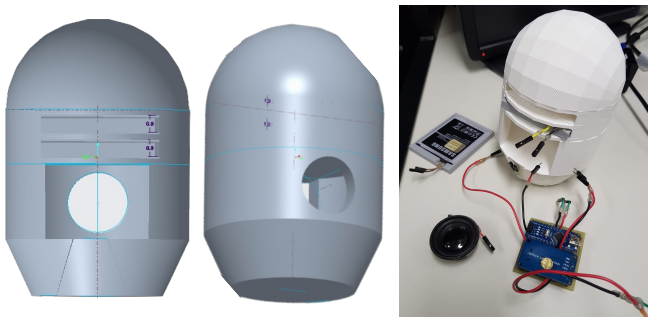
Once the circuit board is developed, we move on to the design phase. Fig. 5 shows the first version of our 3D prototype. In this version, we focused on four main points: (1) the ergonomics to fit the hand and hold the prototype during the Heimlich maneuver, (2) an appropriate space to accommodate the circuit board, (3) a path for the FSR sensor wires, and (4) the height of the 3D prototype, to indicate the correct position for performing of the Heimlich maneuver. However, we realized that we would need dedicated space for both the batteries and the speaker, and that the wires path inside the 3D prototype made it difficult to position the FSR sensor.



(a) (b)

Fig. 5: First version of the 3D prototype.

Fig. 6 shows the final version of our 3D prototype. Note that in addition to fixing the issues found in the first version, we have also made it modular. For example, it was very easy to disconnect the battery and remove the case to charge it outside. Furthermore, if any component fails, it can simply be swapped out without affecting another component.



(a) (b) (c)

Fig. 6: Final version of the 3D prototype.

4. CONCLUSION

This project presented a low-cost electrical circuit prototype to help with the Heimlich maneuver, which has the potential to contribute to the protection of children's lives in school environments. Besides the prototype development, we plan to make this entire project available in the future, making it accessible to everyone. In this regard, we hope you have enjoyed the project, as its success will help disseminate it quickly to all schools in Brazil and save children's lives.

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