CPR for ALL: A Low Cost CPR Training & Feedback Device For Low Resource CPR Training Programs

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Extended Abstract

Bystander CPR training primarily uses high quality mannequins in order to simulate anatomically-correct CPR procedures. However, high-quality CPR mannequins can be expensive, making it difficult for some organizations to afford them [1]. As a part of our INFO 6940 Participatory Design & Making course at Cornell Tech, we partnered with 4 Weill Cornell Medicine emergency physicians to develop a low cost version of a CPR training model that can be used by the Pakistan Life Saver's Program (PLSP), a low-resource CPR training program in Pakistan responsible for providing CPR training to school children nationwide [2]. Using digital fabrication methods, user interviews, empathy mapping, rapid prototyping techniques and usability testing, we created a low-cost, reproducible CPR training model that provides immediate feedback on chest compression depth and rate.

We were challenged to build a low cost version of a CPR model that correctly simulates chest compression necessary to train the public in high quality CPR which would be used in CPR training programs conducted in Pakistani schools by the non-profit PLSP. The PLSP is a non-profit organization that aims to improve access to emergency medical services in Pakistan. The organization provides CPR training and other training to healthcare professionals, first responders, and the general public. As of 2022, CPR training is now required in the national school curriculum at all education levels in Pakistan [2]. PLSP is responsible in part for conducting these training programs in schools with students in 6th-12th grade. Currently, PLSP has limited high quality CPR mannequins and has pillows available for each trainee to serve as CPR training devices. Our goal was to build a CPR training model to replace these pillows that would be affordable to build, easy to reproduce, and scalable for the new CPR school curriculum.

We used user interviews, empathy mapping, rapid prototyping and iterative usability testing to refine the scope and design of our digitally-fabricated CPR training model.

We started by interviewing 4 Weill Cornell Medicine emergency physicians to learn more about their experiences learning CPR and training medical students in CPR, how they monitor student CPR performance during training sessions, what types of mannequins or other technologies they used in their training sessions, and lastly we asked them to describe the most important and essential aspects of delivering high quality CPR, which are compression depth at 2-2.5 inches and rate at 100-120 compressions per minute for 2 minutes minimum.

Next, we completed an empathy mapping activity as a team and alongside one of the Weill Cornell physicians who works closely with the PLSP. We identified and discussed how a student from 6th to 12th grade would think, feel, communicate, and do when receiving CPR training in a school environment. We concluded that our final CPR training model should aid in building student's confidence in administering CPR, increase their engagement with the CPR model, and help them quickly monitor their own CPR compression depth and rate by providing accurate feedback.

After discussing a range of available and affordable materials that could simulate the recoil and compression of a chest, we landed upon a standard kickball. Kickballs and other types of balls used for games are widely available wherever students have room to play. Relying on recoil, durability and size of a standard 8" kickball, we began by building a cardboard ball-holder that served to secure the kickball's movement and act as a platform to compress the ball underneath. We cut slots in the cardboard frames to attach stabilizing crossmembers to distribute compression force and minimize wobble. We laser-cut a ⅛"-thick wood panel to quickly make and test our initial ball-holder idea, using nuts, bolts and washers in our makerspace (Figure 1).

Figure 1.

We conducted iterative usability tests with one Weill Cornell emergency physician, one medical student, and two FDNY firefighters who served as CPR-certified trainers for the general public. We met individually with each professional to showcase our cardboard kickball model to ensure that its compressions and performance accurately simulated compressions on a human body. We received positive feedback and additional suggestions to consider portability, storage, and durability of our design that we took into consideration in our final making process.

To build our final design, we used laser cutting and 3D-printing to fabricate parts of the compression training model. We laser cut ¼”- and ⅛”-thick plywood for the top and outer boxes, and the stabilizing crossmembers respectively. We 3D-printed a singular unit to hold all electronic components (microcontroller, LED strip, ultrasonic depth sensor) that can be clamped and mounted onto the side of the wood box. We further tested our final laser-cut and 3D-printed model assembly with CPR-trained and certified physicians and Cornell Tech students to identify and design for concerns about comfortability of the top wood box, and understandability of our feedback system.

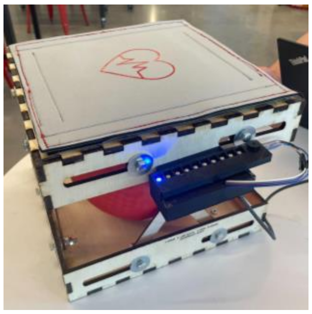

Figure 2.

Our final design is a compartmentalized, affordable, and adjustable CPR compression-only training model that provides immediate compression depth and rate feedback via a buzzer and LEDs (Figure 2). Our design consists of a kickball, laser-cut wood boxes to hold the kickball, laser-cut stabilizing crossmembers attached with nuts, bolts and washers, and a mountable 3D-printed electronics holder to simplify and steady the depth sensor, microcontroller, and LED strip that comprises the feedback system. We used the Adafruit QT-Py miniature Arduino microcontroller, Sparkfun’s Ultrasonic Distance Sensor HC-SR04, a 5V Piezo buzzer, and addressable RGB miniature LEDs to build our feedback system. Our final model includes a removable neoprene fabric cover to minimize injury to hands while practicing CPR compressions on our model. Our use of a kickball, laser-cut box and neoprene fabric correctly simulate the pressure and recoil of a human chest when performing real CPR, as commented by emergency medicine physicians and CPR-certified trainers in the FDNY.

When a user practices CPR compressions on our design, an LED strip on their right that informs them on the depth accuracy of their compressions: a yellow light means they need to increase the depth of their compressions, a green light means they are compressing at exactly the right depth (2-2.5inches), a red light means they are compressing too deeply, and the blue light signifies that they have allowed the model to fully recoil post-compression, which is essential for administering high quality CPR (Figure 3). The buzzer will also trigger when they compress at the correct depth.

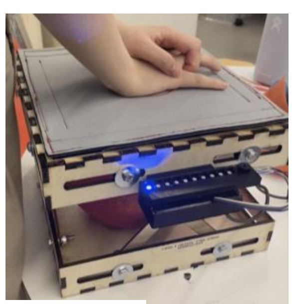

Figure 3.

To make our model portable and scalable for CPR programs in schools, we created a carrier platform that includes straps for easy transport. We used laser-cut wood as a platform to support the model, and attached canvas straps to the platform that wrap around the model to secure it (Figure 4).

We’ve created a portable, affordable, and adjustable CPR compression training device that provides quick feedback for students of any age and expertise. To address affordability, we used physical materials like wood, fabric, cardboard and a standard kickball that would be accessible in a variety of areas around the world, and materials accessible in a standard makerspace. Our CPR training model will cost ~$80 USD, but may be cheaper depending on adjustments and different markets in developing countries such as Pakistan. Our design can be easily adjusted, as the wood box and carrier platform can be scaled to accommodate different ball sizes. This allows for customization and adjustability depending on the needs and resources available for different CPR training programs. We’ve also created an easily replicable design by using standard electronics components and designing a 3D-printed holder that allows for easy assembly of the feedback system with instruction. We used generic PLA filament that a standard makerspace with a 3d-printer would have, as well as a standard laser cutter capable of straight line vector cuts. To further this point, we’ve created an ‘Instructables’ document to increase accessibility to low cost CPR models and instruct others on how to build this model themselves in other makerspaces in detail [3]. In the future, we hope to improve our design by decreasing the sensitivity of the depth sensor to provide more accurate compression feedback, and replace the neoprene fabric with fabric laser-etched with a graphic of a ribcage to orient the user to the part of the body where they will be performing CPR in case of a real life emergency.

Figure 4.

In conclusion, we partnered with Weill Cornell Medicine emergency physicians to develop a low cost version of a CPR training model that can be used by the PLSP, a low-resource CPR training program in Pakistan responsible for providing CPR training to school children nationwide. Using rapid prototyping techniques, usability testing, and digital fabrication methods, we created a low-cost, reproducible CPR training model that provides immediate feedback on chest compression depth and rate that can be used by low-resource CPR training programs.

References

[1] Hoskins, D. S. (2016). “*CPR Training: Time for a Change*”. Journal of Emergency Medical Services, 41(8), 46-53.

https://propakistani.pk/2022/06/21/cpr-training-will-now-be-mandatory-at-all-educational-levels/

[2] CPR for All Instructables: https://docs.google.com/document/d/1pwOQY6LLWeu2-WrqhiwFXcap4NURnqS5RL8z-PJ1cMg/edit