

## Design of Automatic External Defibrillator Training Device with LCD Screen, Controllable with Android-Based Devices

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### Highlights

- The developed AED training device provides visual and audio guidance.
- The device is fully controllable via Android-based mobile application.
- The system supports effective training for hearing-impaired individuals.

Article Info	Abstract
<b>Article History:</b> Received: August 5, 2025 Accepted: December 29, 2025	Automated External Defibrillators (AEDs) are critically important for rapid intervention in cases of sudden cardiac arrest. For this reason, their presence in crowded places such as shopping malls and airports has become a legal requirement in some developed countries. However, for effective use, trained individuals must also be available. Considering that first aid may be needed at any moment, promoting the use of AEDs is highly significant. In this context, it is essential to provide hands-on basic life support training and ensure access to the necessary equipment during the training process. Most current educational devices only offer voice commands, which limits accessibility for individuals with hearing loss. In this study, a microcontroller-based AED training device prototype has been developed. Compared to existing devices, it offers improved features such as visual instructions via an LCD screen, color-coded LED alerts for each step, and remote control through an Android application.
<b>Keywords:</b> Automatic External Defibrillator; AED Training Device; Hearing Impaired; First Aid Training	

### Android Tabanlı Cihazlarla Kontrol Edilebilen, LCD Ekranlı Otomatik Eksternal Defibrilatör Eğitim Cihazı Tasarımı

Makale Bilgileri	Öz
<b>Makale Tarihiçesi:</b> Geliş: 5 Ağustos 2025 Kabul: 29 Aralık 2025	Otomatik Eksternal Defibrilatör (OED) cihazları, ani kalp durmalarında hızlı müdahale için kritik öneme sahiptir. Bu nedenle, insan yoğunluğunun fazla olduğu alışveriş merkezleri ve havaalanları gibi mekanlarda bulundurulması, gelişmiş bazı ülkelerde yasal bir zorunluluk haline gelmiştir. Ancak, cihazın etkin bir şekilde kullanılabilmesi için, cihazı kullanabilen bireylerin de bulunması gerekmektedir. İlk yardım müdahalelerinin her an gerekli olabileceği gerçeği göz önüne alındığında OED kullanımının yaygınlaştırılması oldukça önemli bir konudur. Bu bağlamda, temel yaşam desteği eğitimlerinin uygulamalı bir şekilde verilmesi ve eğitim sürecinde gerekli ekipman ve cihazlara erişimin sağlanması gerekliliği ortaya çıkmaktadır. Mevcut eğitim cihazlarının çoğu yalnızca sesli komutlar sunmakta, bu da işitme kaybı bulunan bireyler için erişim kısıtı oluşturmaktadır. Bu çalışmada, sesli komutların yanında LCD ekran üzerinden görsel bilgilendirme sunan, her adım için farklı renkte LED uyarılar içeren, android uygulama entegrasyonu ile mobil cihazlar üzerinden kumanda edilebilen, mikrodenetleyici tabanlı, mevcut OED eğitim cihazlarına göre iyileştirilmiş bir OED eğitim cihazı prototipi geliştirilmiştir.
<b>Anahtar Kelimeler:</b> Otomatik Eksternal Defibrilatör; OED Eğitim Cihazı; İşitme Engelli; İlk Yardım Eğitimi	

## 1. Introduction

Early and correct intervention and first aid applications significantly increase patient survival rate and quality of life (Nielsen et al. 2013). The main purpose of first aid is not only limited to ensuring the survival of the patient; it is also to ensure that the patient can continue their life in a healthy way by preserving their quality of life. It has been shown in many clinical studies that basic life support (BLS) and advanced life support (ALS) applications significantly reduce pre-hospital mortality rates. On the other hand, delayed or incorrectly performed first aid applications may cause the patient to continue their life with serious neurological sequelae or permanent organ failures despite living (Agerskoy et al. 2017). This situation negatively affects both individual quality of life and imposes an additional economic burden on health services in society.

Especially in cardiac emergencies, the duration of intervention is one of the most important factors that directly determine patient prognosis. According to the World Health Organization (WHO) data, sudden cardiac arrest is among the top causes of death worldwide and the mortality rate is extremely high in cases where early intervention is not performed. In the event of sudden cardiac arrest, defibrillation attempts performed within the first 3–5 minutes can increase the survival rate by 50–70%, while this rate decreases by 10–12% with each passing minute. In the clinical literature, repeated studies have shown that delayed defibrillation has a decisive effect on neurological survival. The cessation of blood flow initiates hypoxic-ischemic damage in the brain and other vital organs within a few seconds, which leads to irreversible neurological consequences (Hansen et al. 2014). AEDs have been developed to intervene in such situations and play a vital role in first aid basic life support applications (T.C. Sağlık Bakanlığı, 2020). These devices are used to eliminate electrical disturbances in

the heart and restore normal rhythm (T.C. Sağlık Bakanlığı, 2020).

Automatic External Defibrillator (AED) devices guide the user by suggesting a shock in fatal arrhythmias such as ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT) and reduce the risk of error. AEDs perform rhythm analysis and only recommend defibrillation in rhythms that require shock, thus minimizing user errors. Institutions such as the European Resuscitation Council (ERC) and the American Heart Association (AHA) strongly recommend the use of AEDs in basic life support protocols.

Since the need for first aid interventions arises suddenly, the widespread use of AEDs is of critical importance (Agerskoy et al. 2017). Effective use of the device is only possible with individuals who know how to use it (Walters et al. 2017). Therefore, the widespread use of AEDs should not be limited to the provision of devices, but individuals should also be trained to use these devices in order to increase AED use rates in society (Pollack et al. 2019), (Lin et al. 2013). Studies have reported that the rate of intervention in emergencies by individuals who receive first aid training increases significantly, and this is directly reflected in survival rates. On the other hand, existing AED training devices generally work based only on voice commands, limiting the full participation of hearing impaired individuals in the training process. In this study, an AED training device developed to enable hearing impaired individuals to receive effective training is presented. The designed device has innovative features such as LCD screen indicator, LED-supported directions for each step and android-based mobile application integration. The device supports the active participation of users who have difficulty perceiving voice commands in the education process by guiding the user with visual and light commands.

## **2. Material and Methods**

### **2.1. App Inventor**

App Inventor is a visual block-based software development platform that allows individuals without programming knowledge to develop mobile applications (Özding, 2015). This platform allows individuals of all ages to participate in the application development process thanks to its user-friendly interface. This project, which was first initiated by Google, was taken over by the Massachusetts Institute of Technology (MIT) in 2013 and offered free of charge to a wide range of users for educational purposes. Instead of writing traditional lines of code to create application logic, developers can visually build application logic by bringing together various functional blocks with the drag-and-drop method (Roy, 2012).

App Inventor is a completely online system that does not require any software installation. In this respect, users can participate in the mobile application development process only through an internet browser. The platform offers various tools such as a design interface, block editor, real Android devices and virtual emulators during the application development process, allowing both the visual design and functional structure of the application to be built (Smutný, 2011). While the design screen is used to create the external appearance and user interface of the application, the behavioral and logical processes of the application are defined through the block editor. These two components come together to make the application both effective in terms of user experience and functionally working properly. An educational stethoscope design that can be controlled via an Android-based application with App Inventor was presented by Sari Y. et al (Sari et al. 2024).

In order to develop a successful application with App Inventor, it is necessary to understand the basic components offered by the platform and how they interact with each other. For example, after the screen

structure and content elements of the application are positioned on the design interface, the functions of these elements are configured using the block editor (Pekyürek et al. 2024). While the design screen provides a visual area where user interface components such as buttons, text boxes, and images are placed; the block editor is the section where the behaviors of these components are programmed. The MIT App Inventor Design Screen and the tasks of the sections on this screen are shown in detail in Figure 1 (MIT, 2025).

On the other hand, the block editor is an event-based programming area where users construct the internal logic of the application. Thanks to this editor, users can define the operations that need to take place in the application depending on events and conditions. In this system, which is structured with the drag-and-drop method, each block represents a programming expression and the functionality of the application is revealed by combining the blocks in a logical order. The MIT App Inventor Block Editor and the functions of the sections in this editor are shown in Figure 2 (MIT, 2025).. The block editor stands out as an important tool that allows even users with no programming experience to understand the software logic and develop applications. Since the visual programming language offers a more intuitive structure than traditional coding, it is widely preferred, especially in educational environments and in beginner-level software teaching.

### **2.2. Circuit Structure and Components**

The circuit diagram of the designed device is shown in Figure 3. Figure 3 includes a detailed circuit schematic showing the electronic components and connections of the device. The circuit includes a HC05 Bluetooth module, a PAM8403 audio amplifier, a 3.95", 320x480 ILI9488 TFT color LCD display with an SD card module, a speaker, resistors and LEDs. The LCD display is connected to pins 22-53 of the Arduino Mega and the voice commands are recorded in the SD card.

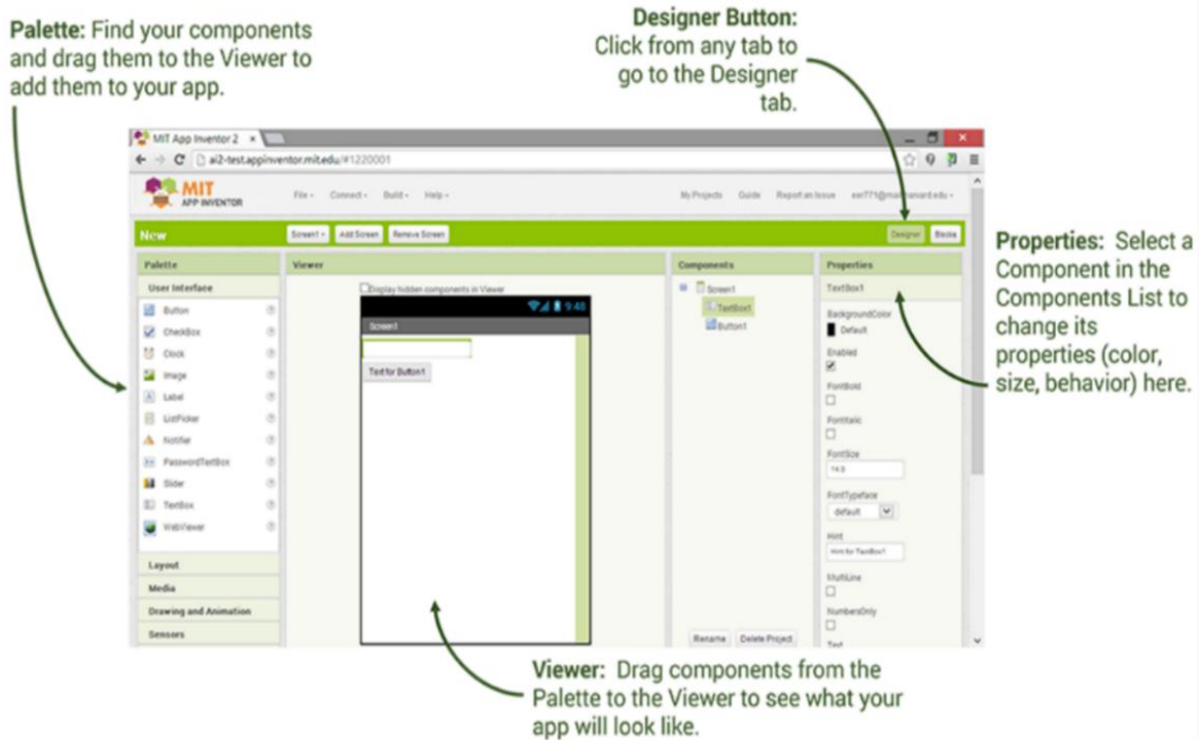


Figure 1: MIT App Inventor Design Editor

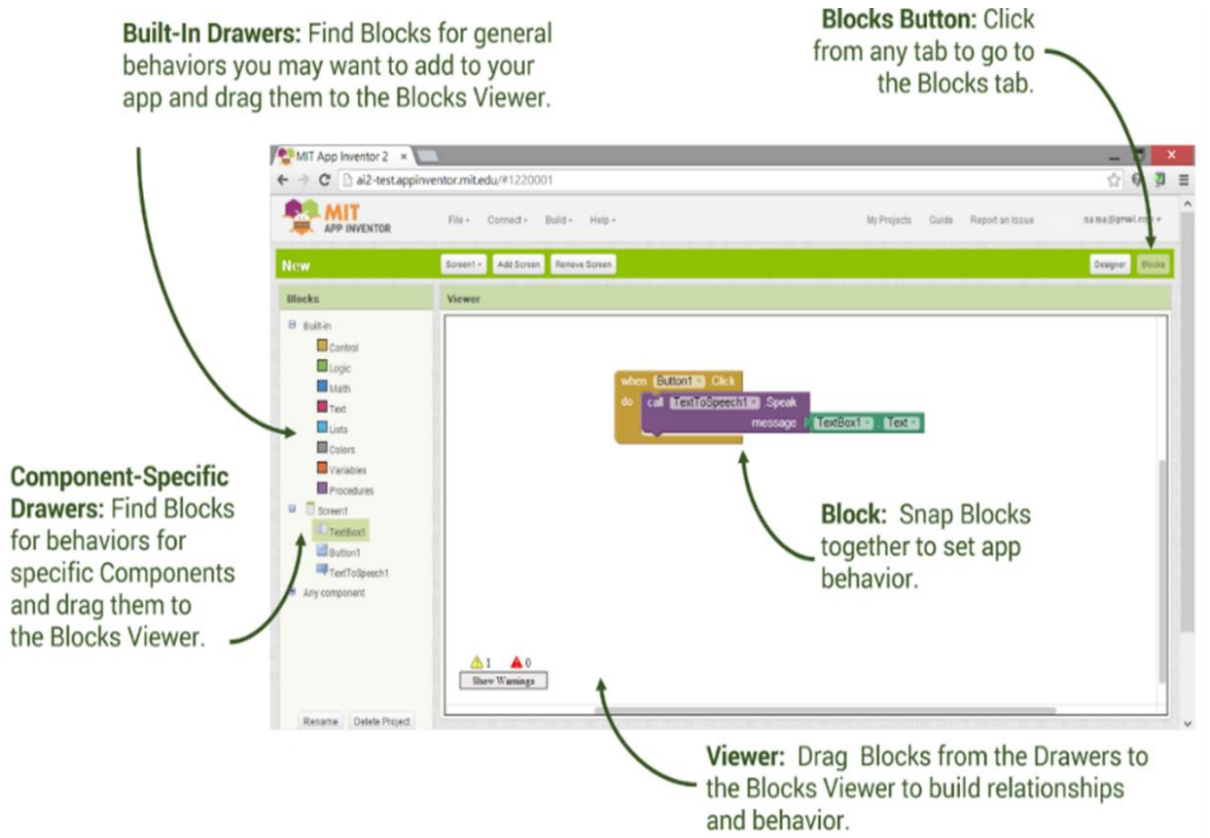


Figure 2: MIT App Inventor Block Editor

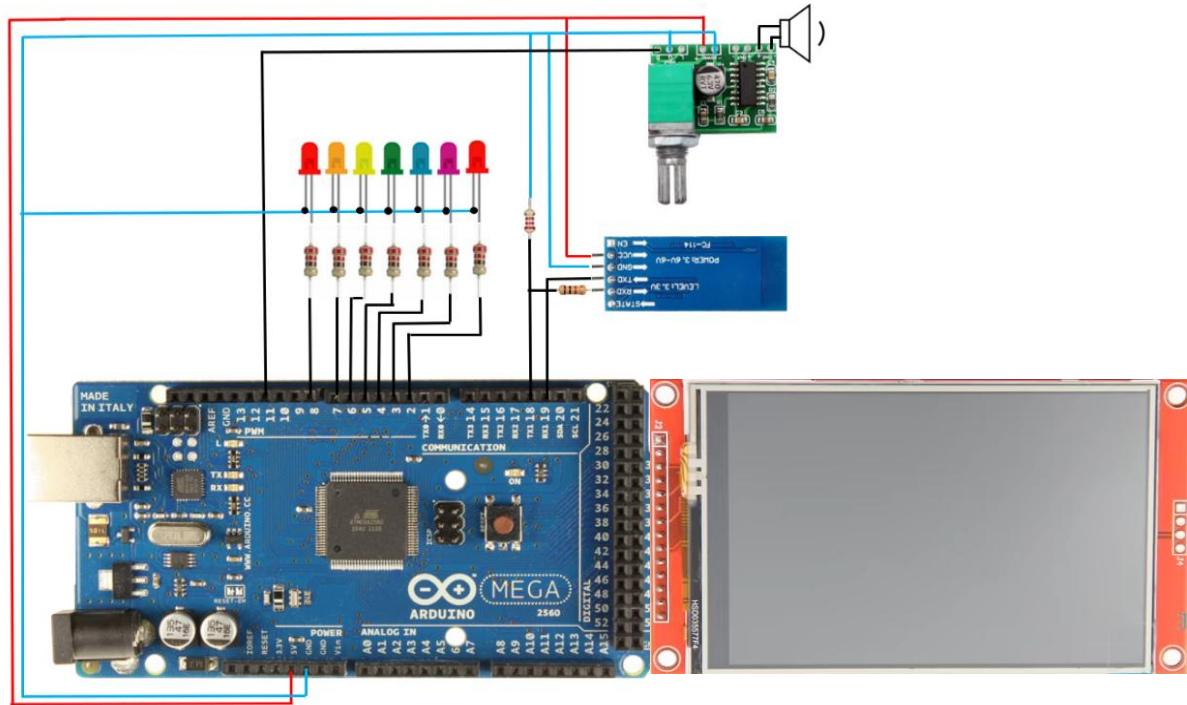


Figure 3: Circuit diagram of the designed AED Training Device

### 2.3. Circuit Structure and Components

In this study, an Android-based remote control application was designed using the MIT App Inventor platform in order to control the developed OED Education Device via mobile devices. Thanks to the

visual and block-based programming structure of App Inventor, a user-friendly and functional interface was created, and the basic control functions of the application were programmed via this structure. The block editor screen of the developed mobile application is presented in Figure 4.

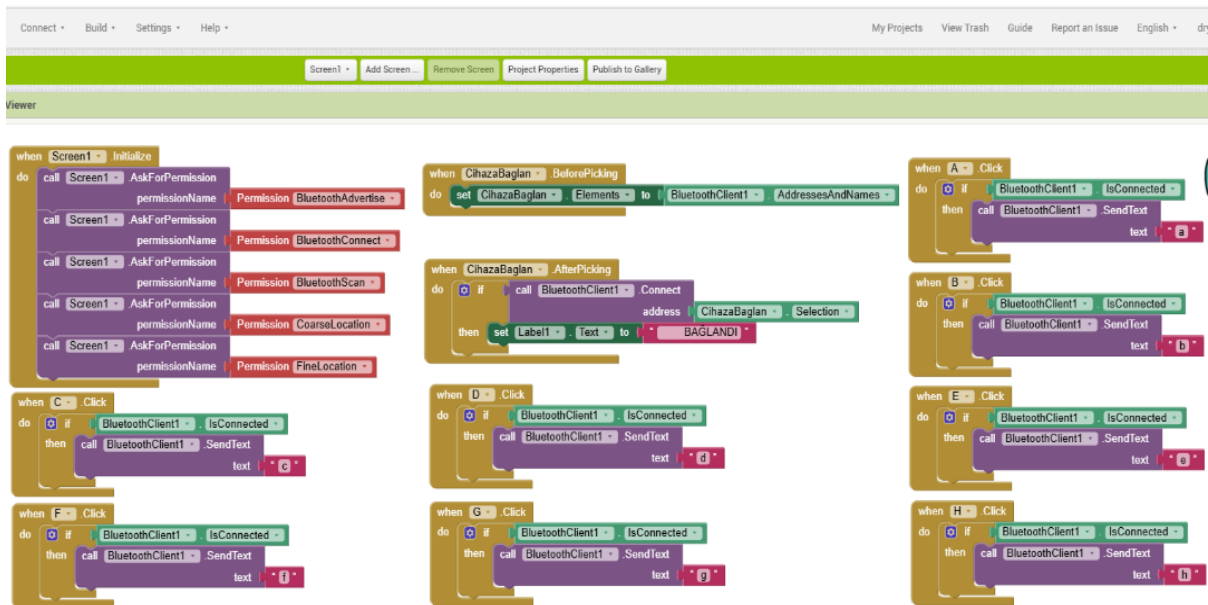


Figure 4: Block editor screen of the remote control application developed in MIT App Inventor

This screen shows in detail how the functional logic running in the background of the application is structured. On the block editor, the Bluetooth commands that provide communication with the device are organized in blocks in a certain order. Each operation is associated with a specific command triggered as a result of user interaction, and these commands are sent via the application to control the device.

The developed Android remote control application establishes a direct connection with the device via the Bluetooth module and is structured to control various functions. The screenshot of the user interface of the application is given in Figure 5. This screen includes a "Connect" button that allows users to connect to the device, as well as "Start" and "Stop" buttons for basic control operations, along with six different command buttons. These buttons are paired with specific characters via the block editor, so that each user interaction results in a specific command being sent. These characters sent via the application are received by the microcontroller on the device, and predefined functions are performed according to these characters.

When the block editor screen is examined, it is seen that each button is represented by a specific letter character. For example, the "Start" button is assigned the character 'a' in the block editor, and when this button is pressed, the application sends the command 'a' to the microcontroller via Bluetooth. Similarly, different characters are assigned to other command buttons, and various functions of the device are controlled via these characters. This structure allows for the creation of a communication protocol that is both simple and effective. Only the "Connect" button is different from this structure, and is associated with a special procedure that initiates the connection with the device. In this way, after the user has successfully established a connection with the device, he/she can easily use the

functions offered by the application through other buttons.



**Figure 5:** User interface screen of the developed application

A sample section of the software of the developed application is shown in Figure 6. This software section more clearly reveals how the application is structured, how user interactions are converted into commands, and how these commands interact with the device. This structure, organized in the form of visual blocks, increases the understandability of the application and offers a significant advantage, especially for users with little experience in software. The remote control application developed with these features is a practical control tool that can be used for educational purposes.

```

67 basla:
68     if(voice == "a")
69     {
70         voice="";
71         mylcd.Fill_Screen(0x0000);
72         digitalWrite(2, HIGH);
73         digitalWrite(3, LOW);
74         digitalWrite(4, LOW);
75         digitalWrite(5, LOW);
76         digitalWrite(6, LOW);
77         digitalWrite(7, LOW);
78         digitalWrite(8, LOW);
79         tmrpcm.stopPlayback();
80         tmrpcm.play("a.wav");
81         mylcd.Set_Text_colour(RED);
82         mylcd.Set_Text_Size(4);
83         mylcd.Print_String("CALL EMERGENCY HELP", 15, 20);
84         mylcd.Set_Text_colour(BLUE);
85         mylcd.Print_String("EMERGENCY HELP NUMBER", 1, 70);
86         mylcd.Set_Text_Size(5);
87         mylcd.Print_String("112", 200, 125);
88         for(i=0; i<450; i+=1)
89             { delay(10);
90                 while (baglanti.available())
91                     {
92                         char c = baglanti.read();
93                         voice += c;
94                     }
95                 if (voice.length() > 0)
96                     {
97                         Serial.println(voice);
98                         if(voice != "")
99                             {
100                                 goto basla;

```

**Figure 6:** A part of the software of the developed application

### 3. Device Usage

The AED (Automatic External Defibrillator) device is placed in a suitable position next to the patient in case of emergency and made ready for use. If the device is not a model that starts working automatically when the cover is opened, it must be turned on manually by

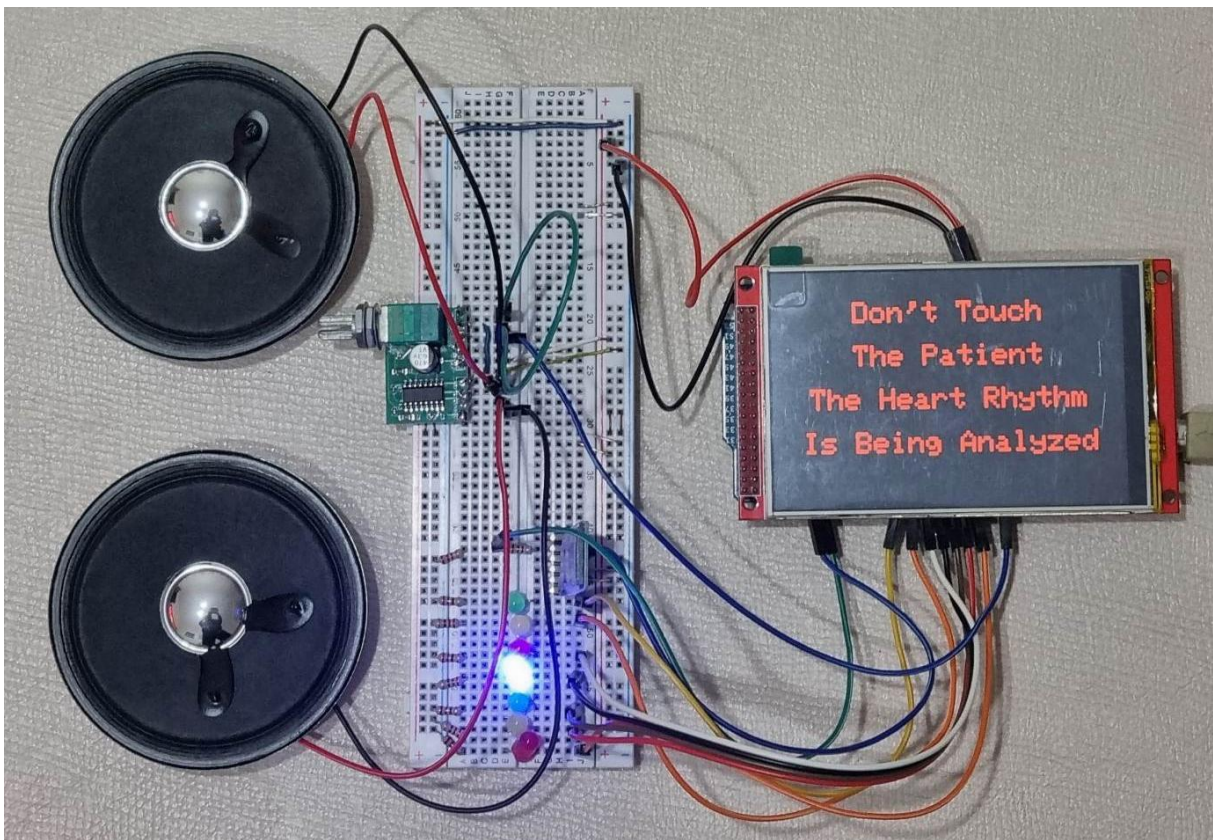
pressing the power button on the device. After the device is turned on, the system informs the user step by step through integrated voice prompts and helps them perform the correct intervention. These voice prompts are of critical importance, especially for individuals with limited first aid knowledge.

The OED training device developed in this study was designed as a training model that imitates the functional structure of a real AED. The training process is carried out by an instructor controlling the device via an Android-based remote control application. The instructor enables the device to give audible and visual warnings by pressing certain buttons on the mobile application. Thanks to these prompts, individuals participating in the training are guided step by step in a manner similar to a real intervention scenario and encouraged to act consciously.

When the “Connect to Device” button in the mobile remote control application shown in Figure 5 is pressed, a connection is established with the device via Bluetooth technology. After the connection is successfully established, each of the buttons on the application interface is configured to perform a specific









function. The functional descriptions of these buttons are given in detail in Table 1. Each button represents a different step in the training process and allows the device to give the audio and visual warning specific to that step. Thanks to this structure, both the trainer and the individual receiving the training can continue the process in a controlled and scenario-appropriate manner.

An image representing a moment when the developed device is actively working is presented in Figure 7 as an example. This image is an important reference in terms of showing the status of the device during use and the visual warnings it offers to the user. This structure of the device increases the sense of realism in practical training and contributes to the development of users practical skills.



**Figure 7:** An example of an image of the device in operation

**Table 1:** Functions of the remote control application buttons of the AED Training device

	<p>When this button is pressed, the 1st LED becomes active and the following sounds are heard:          ‘CALL EMERGENCY HELP’-‘EMERGENCY HELP NUMBER 112’          ‘Attach the Pad Connector’ (Continuous Repetition)</p>
	<p>When this button is pressed, all LEDs, LCD and sounds are turned off.</p>
	<p>When this button is pressed, the 2nd LED becomes active and the following sounds are heard:          ‘Adult pads are attached to the device, expose the patient's chest, remove the pads from the package and peel off the protective tapes’          ‘Apply the pads by pressing them firmly onto the bare chest as shown in the figure’ (Continuous Repetition)</p>
	<p>When this button is pressed, the 3rd LED becomes active and the following sounds are heard:          ‘Child pads are attached to the device, expose the patient's chest, remove the pads from the package and peel off the protective tapes’          ‘Apply the pads by pressing them firmly onto the bare chest as shown in the figure’ (Continuous Repetition)</p>
	<p>When this button is pressed, the 4th LED becomes active, the LCD screen image is seen in Figure 7 and the following sounds are heard:          ‘Do not touch the patient, the heart rhythm is being analyzed’ (Continuous Repetition)</p>
	<p>When this button is pressed, the 5th LED becomes active and the following sounds are heard:          ‘Shock is recommended, wait, do not touch the patient’          ‘Do not touch the patient, shock will be applied’          ‘3-2-1’          ‘Shock applied. You can touch the patient’          ‘Give 30 heart massages in harmony with the vocal rhythm and give 2 breaths..... Now give 2 breaths’ (Continuous Repetition)</p>
	<p>When this button is pressed, the 6th LED becomes active and the following sounds are heard:          ‘Pacemaker detected’ (Continuous Repetition)</p>
	<p>When this button is pressed, the 7th LED becomes active and the following sounds are heard:          ‘Shock is not recommended, you can touch the patient’          ‘Give 30 heart massages in harmony with the vocal rhythm and give 2 breaths..... Now give 2 breaths’ (Continuous Repetition)</p>

#### **4. Functional Validation of the Proposed AED**

##### **Training Device**

The developed AED training device prototype was subjected to functional validation tests to verify the correctness and reliability of its operation. These tests were conducted to ensure that all system components operate synchronously and according to the predefined training scenarios.

First, the accuracy of command sequencing was validated. Each training step was executed in the correct order, and the corresponding audio instructions, LCD messages, and LED indicators were observed to activate simultaneously. The scrolling text feature of the LCD screen successfully provided continuous visual guidance synchronized with the audio commands.

Second, the LED-based visual guidance system was tested by assigning a unique color to each training step. The LEDs responded correctly to each command, providing clear and intuitive visual feedback during the training process.

Third, the Android-based mobile application was tested for communication stability and responsiveness. Control commands sent from different Android-based smartphones and tablets were reliably received by the microcontroller-based system without noticeable latency or communication failure. The QR-code-based access mechanism enabled rapid and user-friendly application access without requiring an additional physical controller.

These validation results confirm that the proposed system operates reliably at the prototype level and fulfills its intended design objectives as an enhanced and accessible AED training device.

##### **5. Conclusion**

In this study, an advanced training device was designed that goes beyond the basic features of existing AED

(Automatic External Defibrillator) training devices and allows individuals with hearing loss to receive effective training. In the designed device, visual information is provided via the LCD screen in addition to voice commands; thus, users are guided in cases where auditory warnings are not sufficient. The scrolling text feature of the LCD screen allows individuals with hearing loss to follow commands more easily and makes an important contribution in terms of accessibility.

The device is supported with LEDs in different colors for each command and is structured as a microcontroller-based. This LED-supported structure increases the visual feedback capability of the device, making the learning process more effective. In addition, a mobile application compatible with Android-based phones and tablets has been developed and integrated into the system instead of traditional physical remote controls. The access link of the mobile application is provided via a QR code to be placed on the device, allowing users to access the application easily and quickly; it also prevents situations such as the remote control being lost or malfunctioning.

As a result, this developed training device; It is an accessible and effective training tool that addresses the needs of different user groups with its audio, visual and mobile supported structure. In this respect, it offers a practical and innovative solution that can be used especially in the fields of first aid and health education.

The current study focuses on the design and prototyping of the proposed AED training device. User-based field studies involving certified instructors and statistical evaluations were not conducted in this phase. Future studies will include ethically approved controlled training sessions and quantitative user feedback analysis to further assess the educational effectiveness of the system.

**Conflict of Interest:** The authors declare that there is no conflict of interest to disclose.

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