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# Design and Development of a Snellen Chart Projector for Myopia Patients with a Patient Response Feature

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**ABSTRACT** Visual acuity (visus) examination is a fundamental procedure for detecting refractive errors, particularly myopia. In practice, visual acuity assessment is still commonly performed using conventional Snellen Chart cards, which have limitations in terms of practicality, display consistency, and result recording. This study aims to design and develop a microcontroller-based Snellen Chart Projector with a patient response feature as an assistive device for visual acuity examination. The developed system consists of integrated software, hardware, and mechanical design, and is capable of displaying Snellen optotypes in accordance with standard letter sizes and a six-meter examination distance. The research methods include system design, functional testing of each component, accuracy testing of the TF-Luna distance sensor, verification of optotype size, and device trials involving respondents accompanied by feasibility assessment using questionnaires. The test results indicate that the system operates as designed, with distance sensor accuracy exceeding 99% and stable, consistent optotype display. Respondent trials demonstrate positive evaluations of the device's feasibility. Therefore, the developed Snellen Chart Projector is considered accurate and feasible for use as an alternative visual acuity examination tool for patients with myopia.

**INDEX TERMS** Snellen Chart Projector, Visual Acuity, Myopia, Microcontroller, Optotype.

## I. INTRODUCTION

The eye is one of the most important sensory organs for humans. However, visual impairments are quite common, ranging from mild problems such as decreased visual acuity to serious conditions that can lead to blindness [1]. According to data from the World Health Organization (WHO) in 2023, approximately 2.2 billion people worldwide experience visual impairment, both near and distance vision. Of this number, it is estimated that one billion cases have not received proper treatment. Globally, the main cause of visual impairment and blindness is refractive error, affecting about 36% of people. Meanwhile, the prevalence of amblyopia is projected to reach 175.2 million cases by 2030 and increase to 221.9 million by 2040 [2]. As a form of screening for visual impairment, visual acuity measurement can be performed.

Visual acuity (visus) is the ability of the eye to see clearly and distinguish objects at a certain

distance, determined by the accuracy of light focusing on the retina [3]. Several studies show that there are various factors that can affect a person's visual acuity, including reading habits, exposure to light from computers or gadgets, and the use of online games [4]. Considering the importance of eye health, especially for individuals in learning age, the researcher plans to conduct this study on students to adults who suffer from nearsightedness (myopia) as research samples.

In daily practice, visual acuity measurement is generally performed using a Snellen chart. This method is simple, familiar, and widely recognized as an effective way to assess visual acuity [5]. The Snellen chart is used to measure visual acuity based on the visual angle, although the results can be written in fractional or decimal form [6]. Visual acuity examination should be performed starting from the right eye, then the left eye, and the results recorded [7]. In visual acuity testing using a Snellen

chart, the patient is asked to sit at a distance of six meters from the chart, which contains rows of letters of varying sizes along with indicator numbers on the side. Visual acuity values such as 6/9, 6/12, to 6/60 indicate decreased vision. For example, a visus of 6/60 means the patient can only see at 6 meters what a person with normal vision can see at 60 meters. The larger the denominator, the worse the visual acuity [1].

The Snellen chart commonly used in hospitals is usually in the form of a white poster with black letters. However, this type of chart is considered less practical because the examination process takes longer. This is due to the need for the examiner to point to letters one by one, making it difficult to use trial lenses simultaneously.

Along with advances in medical technology, visual acuity testing systems using the Snellen chart, which were initially simple white posters with black letters or numbers, have evolved into more modern methods. In a study conducted by Rinaldi Achyar (2020), an electronic Snellen chart based on LED lights was developed, where specific letters or numbers can be displayed as needed by the doctor. This device is controlled via a smartphone application using Bluetooth connectivity [8]. However, in these studies, control via Bluetooth and smartphone applications has the potential for connection or compatibility issues, non-compact device size, and lacks automatic distance detection and result interpretation features.

Another study by Antonio Julio Cesar Abi (2022) developed a Snellen chart device based on an ATmega8535 microcontroller, which transmits data through a transmitter using modulation frequency [9]. However, this device still lights up per row or per letter. A study by Dhendy Dafeta Mahardicha (2023) used a projector system to display Snellen chart plates, where users can change the displayed chart using an Android device via App Inventor software [10]. However, this system does not yet include patient response features, automatic distance detection, or result interpretation. Another study by Nayla Ghassani Azura (2025) developed a digital Snellen chart-based eye test device using a projector, equipped with patient response via keyboard, a TF-Luna sensor to detect patient distance according to standard examination position, and test results that can be processed and printed using a thermal printer for faster documentation [11]. However, the projector used still cannot clearly display Snellen chart letters, the examination is limited to a one-meter distance, and the device design and components are not yet sufficiently compact and portable.

Monitoring systems in electromedical devices require a display medium as an interface between the user and the system. The use of a display enables real-time presentation of examination results. In its development, Human Machine Interface (HMI) technologies such as Nextion can be utilized to enhance system interactivity and user-friendliness[12]. The use of Nextion as a Human Machine Interface (HMI) enables interactive communication between users and medical devices. It provides real-time display of system parameters and allows user input through a touchscreen interface integrated with a microcontroller via serial communication, improving system efficiency, usability, and operational accuracy[13].

Based on previous studies, this research develops a more compact visual acuity testing device using the Snellen chart method that does not require additional equipment, thereby facilitating clinical personnel, reducing diagnostic time, and providing automatic result interpretation. The system utilizes an ATmega 2560 microcontroller, a projector to display the Snellen chart, a TF-Luna sensor for distance detection, and a Thin Film Transistor (TFT) LCD as a patient response interface with a 10-second duration for each question. It also provides visual acuity results, myopia information, and examination history, with results printed using a thermal printer. Although the system automates most processes, operator involvement is still required during the examination. Therefore, this study aims to design and develop a [visual acuity testing device for myopia patients with patient response features.

#### **A. Refractive Errors**

Refractive errors are conditions in which a clear image is not formed precisely on the retina (macula or yellow spot), but instead falls in front of or behind it, and is not focused into a single sharp point. In a normal eye, the cornea and lens function to refract light so that it falls exactly on the center of the retina. The average length of the human eyeball is about 2 cm, and a refractive power of approximately 50 diopters (40 from the cornea and 10 from the lens) is required to focus light onto the macula.

If the total refractive power does not reach 50 diopters, light will not be focused correctly, resulting in refractive errors such as myopia (nearsightedness), which is corrected with a concave lens (-); hypermetropia (farsightedness), corrected with a convex lens (+); or astigmatism, corrected with a cylindrical lens. The types of refractive errors shown in Fig. 1 include myopia, hypermetropia, and astigmatism [14]. Among these,

myopia is the most common refractive error experienced by students [15].

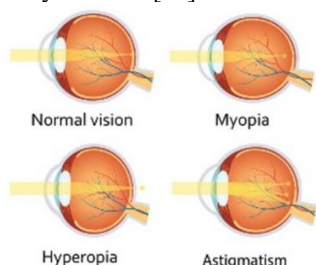


FIGURE 1. Refractive Errors [16]

**B. Myopia**

Myopia, or nearsightedness, is a condition in which the eye has excessive refractive power, causing parallel light rays entering the eye to be focused in front of the retina (macula), as shown in Fig. 2. This condition is generally caused by an eyeball that is longer than normal. Myopia may also occur when the cornea and lens, which function to focus light onto the retina, have abnormalities. To date, the exact cause of an elongated eyeball is not clearly known; however, several factors are believed to increase the risk, including genetic predisposition—where individuals with myopic parents are more likely to develop the condition—limited exposure to sunlight, lack of outdoor activities, vitamin D deficiency, and habits such as reading, using a computer, or watching objects at a very close distance [17].

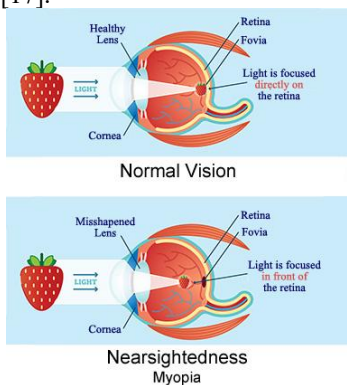


FIGURE 2. Myopia [18]

**C. Snellen Chart**

The Snellen Chart is a commonly used method for visual acuity testing to assess a person’s sharpness of vision as shown in Fig.3. This examination is performed by asking the subject to read rows of letters of varying sizes from a standard distance (generally 6 meters or 20 feet). The results are expressed as a fraction, such as 6/6 indicating normal vision, or 6/12, 6/18, and so on, which indicate reduced visual acuity. For example, a visual acuity of 6/60 means that the patient can only see at 6 meters what a person with normal vision can see

at 60 meters. The larger the number in the denominator, the poorer the visual acuity. Visual acuity testing using the Snellen Chart at a distance of 6 meters can be applied to all age groups, including the elderly, with adjustments made for patient comfort without altering the standard testing distance. This method is simple, quick, and widely used in both clinical practice and eye health screening [19]. The notation for visual acuity (VA) results using the Snellen chart can be expressed in feet, such as 20/20, 20/16, and so on. Alternatively, VA results can also be written in meters using fractional notation, such as 6/6, 6/12, and others, as shown in Figure 3. In 1875, Ferdinand Monoyer introduced decimal notation to facilitate easier comparison with the testing distance. For example, a decimal value of 0.5 corresponds to 20/40 or 6/12, or equivalent results obtained using other testing distances [20].

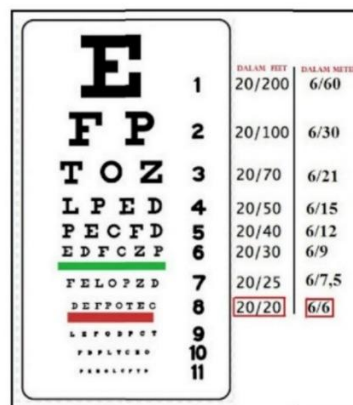


FIGURE 3 Visual Acuity Examination Using the Snellen Chart [20]

**II. SYSTEM DESIGN AND METHODOLOGY**

**A. OVERALL SYSTEM ARCHITECTURE**

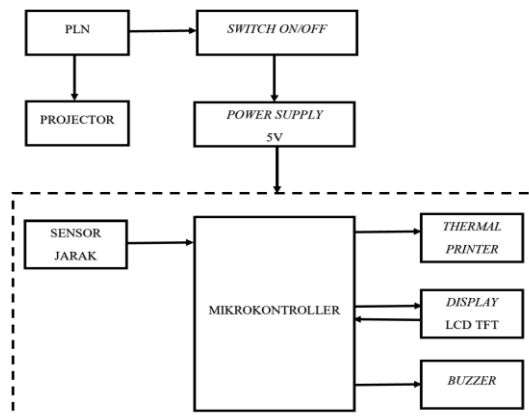


FIGURE 4. This block diagram describes the workflow of the tool to be created

Based on Fig. 4, the 220 V AC voltage from the main power supply (PLN) is supplied to the

projector and power supply unit. The power supply then converts the voltage into 5 V DC, which is used to power the microcontroller, thermal printer, distance sensor, and TFT LCD display. The distance sensor functions to detect the subject's position at a distance of six meters and activates a buzzer as an indicator when the correct distance is achieved. Subsequently, the TFT LCD display sends a command to the microcontroller to operate the thermal printer for printing the results of the visual acuity (visus) examination using the Snellen chart method.

### B. HARDWARE AND SOFTWARE DESIGN

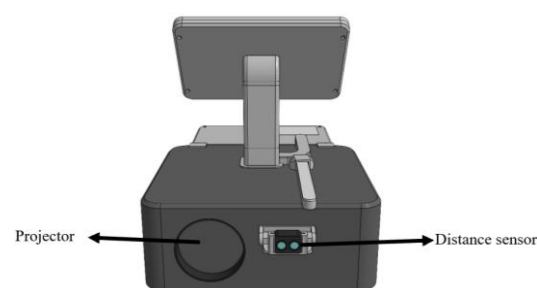


FIGURE 5. Front module design

The front view of the device is shown in Fig. 5. In this section, the projector is used as a medium to project the Snellen Chart onto the testing surface, while the distance sensor is utilized to detect and ensure that the examination distance complies with the specified standard.

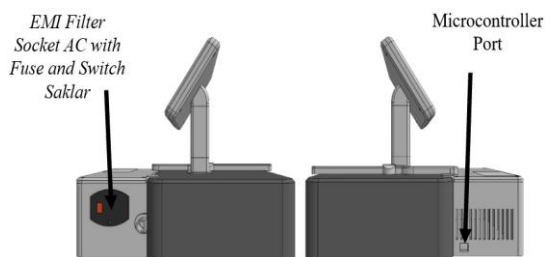


FIGURE 6. Right side and left side module design

The side view of the device is shown in Fig. 6, consisting of the right-side view and the left-side view. The right side features an AC socket equipped with an EMI filter, fuse, and switch, which serves as the power input and system protection. Meanwhile, the left side contains the microcontroller port, which functions as an interface for system communication and programming, and is designed for easy access to support configuration and maintenance of the device.

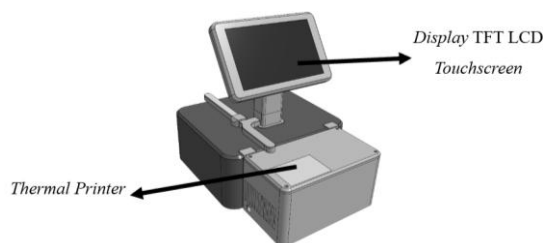


FIGURE 7. Back module design

The rear view of the device is shown in Fig. 7. This section includes a display that functions as a user interface for operating the system and presenting examination information. In addition, a thermal printer is located at the rear side, which is used to print the results of the visual acuity test directly. The placement of these components is designed to facilitate user interaction and support the documentation process of the examination results.



FIGURE 8. Splashscreen on LCD

The splash screen interface design for the visual acuity testing system using the Snellen Chart method is shown in Fig. 8. This display functions as the initial screen of the application, presenting the system identity before the user accesses the main menu.



FIGURE 9. Main menu on LCD

The main menu interface design, which provides several menu options including starting the visual acuity test, information on the Snellen Chart method, information on myopia, and the history of visual acuity test results, is shown in Fig. 9. This menu is designed to facilitate users in accessing each feature of the system.



FIGURE 10. Patient data form on LCD

The patient data form interface design, which is used to input patient identity information including name, age, and gender, is shown in Fig. 10. The data entered in this form is utilized to support the recording and storage of visual acuity test results.

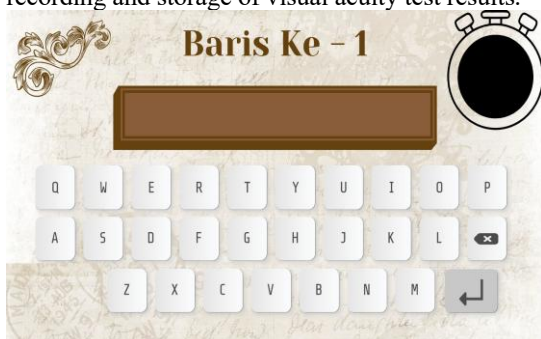


FIGURE 11. Visual acuity test question on LCD

In the visual acuity test question interface shown in Fig. 11, patient input is provided through a keyboard interface using the “button” attribute for letters A to Z.

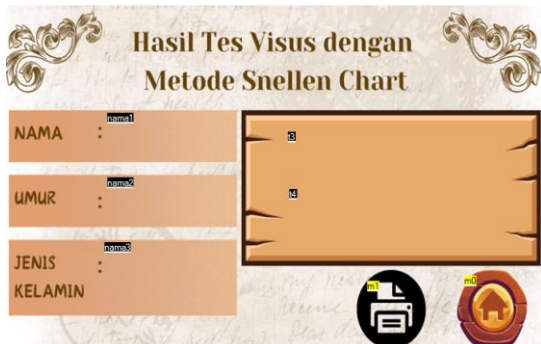


FIGURE 12. Visual acuity test result

The visual acuity test result interface design using the Snellen Chart method is shown in Fig. 12. This display presents patient identity information, including name, age, and gender, along with the obtained visual acuity test results. The interface is also equipped with navigation buttons to print the examination results and return to the main menu.

Nama	Umur	Jenis Kelamin	Visus	Kategori

FIGURE 13. Visual acuity test history

The visual acuity test history interface design using the Snellen Chart method is shown in Fig. 13. This display is used to present previously conducted visual acuity test results in a tabular format, including information such as name, age, gender, visual acuity value, and examination result category. This interface facilitates users in tracking and documenting visual acuity test results.

C. INTEGRATION AND PROTOTYPING

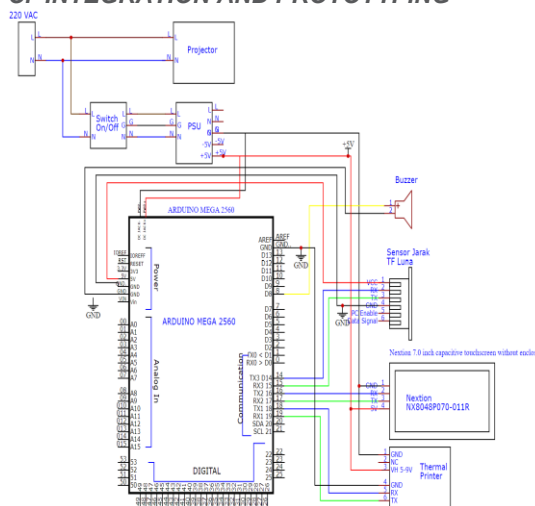


FIGURE 14. Overall system circuit of the device

Fig. 14 shows the overall system circuit of the device. The 220 V AC voltage from the main power supply (PLN) is supplied to the projector to display the Snellen chart projection. When the On/Off switch is activated, the PLN voltage is directed to the 5 V power supply. The power supply then converts it into 5 V DC, which is distributed to the microcontroller, thermal printer, distance sensor, and TFT LCD display. The distance sensor functions to detect the subject’s position at a distance of six meters and activates a buzzer as an indicator when the correct distance is achieved. Subsequently, the TFT LCD display sends a command to the microcontroller to operate the thermal printer for printing the results of the visual acuity test using the Snellen chart method.

III. RESULT AND DISCUSSION

A. PROTOTYPE RESULTS

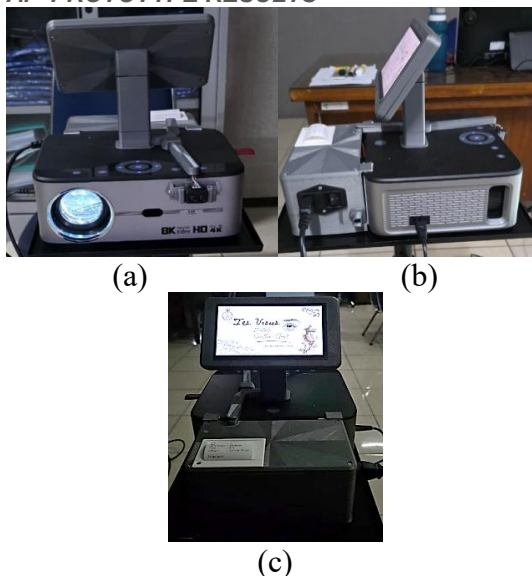


FIGURE 15. Module device (a) Front, (b) Side, (d) Behind

Fig. 15 (a) shows the physical design of the device from the front view. In this view, the projector is used to display the Snellen Chart, while the distance sensor functions to ensure that the examination distance complies with the specified standard. The arrangement of components on the front side is designed to support accuracy and ease of adjustment during the visual acuity testing process.

Fig. 15 (b) shows the physical design of the device from the side view. This view presents the position of supporting components, including the power supply pathway and device ventilation, as well as illustrating the dimensions and structural stability of the device during operation.

Fig. 15 (c) shows the physical design of the device from the rear view. In this section, a TFT LCD touchscreen is visible as the user interface, along with a thermal printer used to print the results of the visual acuity test. The placement of these components is designed to facilitate operation and support the documentation of examination results.



FIGURE 16. Splashscreen

The fig. 16 shows the splash screen display of the visual acuity testing system using the Snellen Chart method, presented on a TFT LCD screen. This display features the title “Visual Acuity Test Using

the Snellen Chart Method,” accompanied by visual elements such as an eye illustration and decorative ornaments representing the system identity. It also includes institutional information indicating the origin of the device development. This screen functions as the initial interface before the user accesses the main menu, providing preliminary information about the type of examination to be conducted. The interface design is simple and informative, aiming to create a professional appearance and facilitate user understanding of the system’s function.

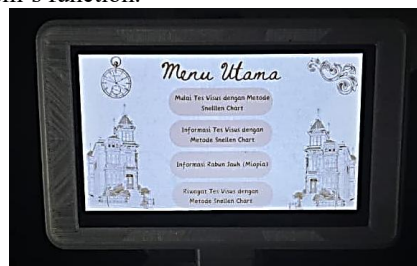


FIGURE 17. Main menu

The fig. 17 shows the main menu interface of the visual acuity testing system using the Snellen Chart method displayed on a TFT LCD screen. The interface presents several menu options, including starting the visual acuity test, information on the Snellen Chart method, information on myopia, and the history of visual acuity test results. This main menu is designed to provide clear navigation and facilitate user interaction in accessing each feature of the system. The layout is arranged in a structured and user-friendly manner to ensure ease of use during the operation of the device.



FIGURE 18. Patient data input

The fig. 18 shows the patient data input interface of the visual acuity testing system using the Snellen Chart method displayed on a TFT LCD screen. This interface provides input fields for patient identity information, including name, age, and gender, along with navigation buttons such as “Back” and “Next.” This interface is designed to facilitate the input of patient data as part of the examination process, ensuring that the collected information can support the recording and storage of visual acuity test results.

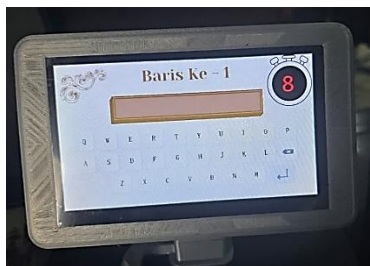


FIGURE 19. Visual acuity test question

The fig. 19 shows the visual acuity test question interface displayed on a TFT LCD screen. This interface presents the test question for the first row (“Baris ke-1”) along with a virtual keyboard that allows patients to input their responses using letter buttons from A to Z. A countdown timer is also displayed to indicate the remaining time for answering each question. This interface is designed to facilitate patient interaction during the test, ensuring that responses are recorded within a specified time limit and supporting the efficiency and accuracy of the visual acuity examination process.



FIGURE 20. Visual acuity test result

The fig. 20 shows the visual acuity test result interface using the Snellen Chart method displayed on a TFT LCD screen. This interface presents patient identity information, including name, age, and gender, along with the obtained visual acuity result, such as the Snellen value and its corresponding category. Additionally, the interface is equipped with navigation icons that allow users to print the examination results and return to the main menu. This design facilitates both the interpretation and documentation of the visual acuity test results in a clear and efficient manner.

**B. SPECIFICATION**

The visual acuity testing device integrates multiple hardware components, including an ATmega 2560 microcontroller, a TF-Luna distance sensor, a thermal printer, and a Nextion TFT LCD display, to ensure accurate measurement and efficient system operation. Equipped with a Nextion NX8048P070 display, the system provides a simple and interactive user interface for conducting visual acuity tests

using the Snellen Chart method. The device operates with a 5 V power supply and incorporates a buzzer as an alarm indicator to assist in distance verification during examination. Additionally, the integration of a thermal printer enables direct printing of test results, supporting efficient documentation. The overall design of the device is compact and practical, making it suitable for clinical use and facilitating ease of operation, as shown in Table I.

TABLE I  
 SPECIFICATION

Device Name	Visual Acuity Testing Device
Supply Voltage	5 V, 5 A
Display	Nextion NX8048P070, 5 V, 1 A
Microcontroller Module	ATmega 2560, 5 V, 1 A
Printer	GOOJPRT QR204, 5 V, 2A
Distance Sensor	TF-Luna, 5 V, 0.15 A
Alarm Indicator	Buzzer, 3 mA
Software	Arduino IDE and Nextion Editor

**C. PERFORMANCE EVALUATION**

In this research, a questionnaire instrument was used to evaluate the feasibility and user satisfaction of the developed device. The questionnaire consisted of 10 items, covering aspects such as ease of use, functional suitability, and performance of the Snellen Chart system. The questionnaire was distributed to 20 respondents who had directly used the device. Each item was assessed using a five-point Likert scale, namely Very Poor (1), Poor (2), Fair (3), Good (4), and Very Good (5). The results of the questionnaire assessment were used as the basis for evaluating the feasibility of the developed device.

The results of questionnaire data processing using descriptive statistical analysis, including minimum, maximum, mean, and standard deviation values, are presented in Table II. The analysis was performed using the Statistical Package for the Social Sciences (SPSS) software.

Overall, the results of the questionnaire data analysis show that the total item score obtained a mean value of 46.75 out of a maximum score of 50. This value indicates that the developed Snellen Chart Projector falls into the “very good” category based on respondents’ perceptions. The total standard deviation value of 3.945 suggests that the distribution of respondents’ answers is relatively homogeneous, indicating consistent perceptions of the device among respondents.

TABLE II  
 DESCRIPTIVE STATISTICAL ANALYSIS RESULTS OF THE QUESTIONNAIRE USING SPSS

	N	Minimum	Maximum	Mean	Std. Deviation
1. To what extent did you use the Snellen Chart Projector in accordance with the provided instructions?	20	4	5	4.65	.489
2. How satisfied are you with the performance of the Snellen Chart Projector in assisting visual acuity (visus) examination for patients with myopia?	20	3	5	4.65	.587
3. In your opinion, how easy is the Snellen Chart Projector to use during the visual acuity examination process??	20	3	5	4.65	.587
4. How comfortable were you when using the Snellen Chart Projector during the visual acuity examination?	20	4	5	4.85	.366
5. To what extent does the patient response feature of the Snellen Chart Projector assist the visual acuity examination process?	20	4	5	4.70	.470
6. How would you rate the safety aspect of using the Snellen Chart Projector during eye examination?	20	4	5	4.75	.444
7. In your opinion, how effective is the Snellen Chart Projector in assisting the detection or evaluation of myopia?	20	3	5	4.45	.686
8. How would you rate the clarity and contrast of the letters displayed on the Snellen Chart Projector compared to the conventional Snellen Chart (card)?	20	3	5	4.70	.571
9. How likely are you to recommend the use of the Snellen Chart Projector to healthcare professionals or other healthcare facilities?	20	4	5	4.75	.444
10. In your opinion, how necessary is further improvement or development of the Snellen Chart Projector?	20	4	5	4.60	.503

#### IV. CONCLUSION.

Based on the results of design, implementation, and testing, it can be concluded that the software, hardware, and mechanical design of the Snellen Chart Projector with a patient response feature have been successfully developed in an integrated manner and function according to the research objectives. Functional testing indicates that all system components operate as intended and effectively support visual acuity examination with good reliability. The TF-Luna distance sensor demonstrates high accuracy, with testing in the range of 300–600 cm showing an error of 0.00%–0.10% and accuracy exceeding 99%, while the buzzer functions properly as an indicator of the standard 6-meter distance. The projected letter size complies with the Snellen Chart standard, and the patient response feature operates effectively in data

acquisition and system interaction. Based on respondent testing and questionnaire results, the device is considered feasible for practical use, although further evaluation and development are still needed to improve system performance.

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