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Microcontroller-based smart foot as an educational tool for teaching reflexology nerve points to visually pmpaired massage trainers and trainees

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Abstract — The limited sense of sight makes it difficult for blind people to get a decent job. One of the jobs performed by the blind is a reflexology massager. Becoming a reflexology massager with visual limitations has several obstacles in learning reflexology. The purpose of this research is to make reflexology educational aids that are easily understood by blind masseurs so that blind masseurs can improve reflexology competence and determine the appropriate massage nerve points. The making of teaching aids is carried out using the Research and Development method with five stages, namely information gathering, planning, development, trials with students and coaches, and evaluation. The results of this study are a prototype in the form of a microcontroller-based smart demonstration leg called Smart Massage Tools. The output of the Smart Massage Tools prototype is sound which is suitable for use by blind people who want to study reflexology independently. Smart Massage Tools have higher time effectiveness and understanding than massage training using manual props.

Keywords – blind, education, microcontroller, productivity, reflexology

I. Introduction

None has the perfect physical condition. Some people are born handicapped. Individuals with disabilities are heterogeneous and minority across the world with varying physical and mental impairments [1]. Recently, the number of visually impaired individuals in the world reached 253 million [2]. In Yogyakarta province, the number of people with social welfare problems requiring social welfare facilities for the visually impaired was recorded at 2,192 people [3]. National Federation of the Blind United States of America: "The real problem of blindness is not the lack of eyesight. The real problem is the misunderstanding and lack of information which exist". If a blind person has proper training and opportunity, blindness is only a physical nuisance. Three things must be done for a blind person to gain independence and empowerment: (1) The blind person must come emotionally, as well as intellectually, to know that he or she truly can be independent and self-sufficient; (2) The blind person must really learn and become competent in those skills (alternative techniques) which will make it possible for him or her truly to be independent and self-sufficient; and (3) The blind person must learn to cope daily with the public attitudes about blindness–with those things that will be said or done to him or her because of other people's misunderstandings and misconceptions [4].

The high number of visually impaired individuals in Indonesia is of great concern to the government. Impaired vision makes it extra difficult for a person to overcome life's challenges, particularly the need for decent employment. One of the occupations available to the visually impaired is that of a masseuse. However, reflexology is difficult to learn for individuals with visual impairments who wish to become professional reflexology masseuses. Extensive, detailed knowledge

of nerve points in the soles of the feet, otherwise commonly known as reflexology, can be mastered through specialized instruction with the help of educational aids. Reflexology has numerous health benefits, including stabilizing blood pressure. Training in the proper application of reflexology is required to reduce errors when manipulating the nerves in the feet [5]. Unfortunately, the visually impaired have a difficult time locating the precise nerve point, which hinders their learning process of reflexology. In addition, a survey conducted at the Janaaha Course and Training Institute (known as LKP) in Kaliurang, Yogyakarta, revealed that there were no independently accessible reflexology educational tools for visually impaired persons. During the COVID-19 pandemic, massage training activities for the visually impaired at the Wyata Guna Bandung Massage Center relied more on technology such as WhatsApp, Zello, Zoom, and YouTube channels. Trainees encountered difficulties both from the online method and the application [6].

Based on the findings of a survey conducted in August 2021 at the Yogyakarta Islamic Welfare Foundation for Visually Impaired Individuals (known as Yaketunis), reflexology massage educational tools in the form of a board with embossed feet and protruding nerve points.

This type of educational tool is still conventional and non-portable, making it impossible to conduct independent learning activities. Due to the restrictions and limitations of using this conventional type of educational tool, our team was then motivated to develop an educational tool using microcontroller technology as a solution to the difficulties encountered by the visually impaired in learning reflexology nerve points. Our team came up with a tool, which we named the Smart Massage Tool. This tool was designed to be accessible to the visually impaired because it relies on touch and sound. According to Rafikayati *et al.* [7] (2020), visually impaired individuals have superior listening and feeling skills, which can be optimized as their primary asset for learning. Meanwhile, existing innovations utilized by the blind are tools of braille learning gloves that are given motor vibration technology to help blind people understand messages for communication. The device will be able to interpret messages by sensing vibrations through the glove on the hand. A vibrating motor is mounted on the back side of the glove which vibrates in a braille pattern when a message is sent [8]. Another innovation that already exists is a sensor-based prototype that allows blind people to walk freely in an unfamiliar environment [9].

This research aims to develop a foot reflexology educational tool that is accessible to the visually impaired. Developing a reflexology educational tool that is accessible to the visually impaired is anticipated to improve their ability to identify the correct massage nerve points and, hence, be better trained to become professional reflexologists. This tool can be used not only by visually impaired individuals learning reflexology but also by normal-visioned individuals who wish to study reflexology's nerve points. It is anticipated that the availability of these educational tools will enhance the professional abilities of visually impaired masseurs and increase the public's confidence in reflexology services provided by visually impaired masseurs.

In the future, this tool can be used in community empowerment programs, especially for those with visual disabilities. Empowerment comes from the word empowered as a translation of the word "power" which is interpreted as increasing ability. The concept of empowerment is a concept originating from the West which was born as a response to the existence of an imbalance of power where humans are very powerful over others (homo homini lupus). Empowerment can be interpreted as a planned and systematic process, which is carried out continuously, both individually and collectively, to develop the power (potential) and abilities contained within itself so that it can carry out social transformation [10].

II. Research Method

This is an applied research. Applied research is research that has practical purposes, seeks knowledge, and attempts to make something significantly better, more effective, and more efficient. Applied research serves to identify solutions to specific issues [11]. The subjects used in this research were three visually impaired individuals from the Yaketunis, comprising two teachers for the visually impaired and one foundation administrator. Interview techniques were used for data collection. Four months were spent producing the tool. The tool was designed to serve as an educational tool for the visually impaired to better learn reflexology. The stages of this research are described as follows.

A. Data Search and Collection

The initial stage of this research involved conducting a literature study by skimming and scanning relevant books, journals, and other literary sources. In addition, a field survey (direct observation) on the needs of visually impaired masseurs and trainees was carried out at this stage to gather information on problems they encountered during their practice and learning.

B. Determining the Size of the Prototype

The second stage of this research involved discussions among the team to determine the right prototype size to be made. Based on the results of the reference search, it was agreed that the prototype size should be based on the measurement of the average left foot size of a 50-year-old adult male.

Fig. 1. 3D design of the smart massage tools. Source: personal documents.

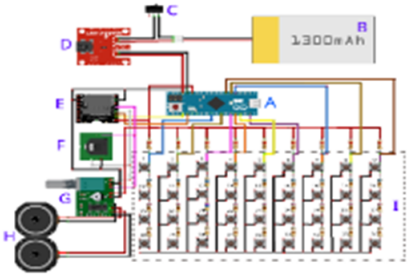

Fig. 2. Schematic design of the prototype. Source: personal documents.

C. Creating the 3D Design

The next stage involved creating the 3D design of the educational tool. The 3D design was created virtually using Autodesk Fusion 360 computer software. The 3D design was divided into three parts: the sole, the instep, and the ankle. The 3D design can be seen in Fig. 1.

D. Creating the Electronic Design

This stage begins with simulation activities using Proteus computer software to obtain ADC (Analog to Digital Converter) values. Each button pressed will have a different ADC value so that it can be used as input on the microcontroller (Arduino Nano). From the different values then made a value for every 36 buttons. The button pressed has a different ADC value so that it can be used as input in the microcontroller. The results of the ADC simulation and schematic layout can be seen in Fig. 2.

Explanation of Fig. 2: (A) Arduino Pro Micro Microcontroller as a circuit controller as desired; (B) Battery as a voltage source; (C) Toggle switch functions to cut off or connect electric current; (D) USB Lipoly Charger, to charge the battery by introducing electric current; (E) DF Player Mini, a sound player module that supports mp3 files; (F) 3.5mm Headphone jack, a device that can produce audio; (G) PAM80403 Amplifier, a small digital amplifier, produces high-definition (hifi) sound that supports 2 stereo channels and can adjust volume with adjustable; (H) Speakers, converting electrical or electrical waves into audio or sound waves; (I) Push Button, as an input instruction to execute commands carried out according to the program.

The electronic design was created using the locations of nerve points on the left foot as parameters. A study by physiotherapist Eunice Ingham showed that the soles of the feet are responsive to stimuli [12]. Blood vessels are extensively distributed throughout the human body, linking one organ to another via their channels. On each sole, 36 nerve points correlate to specific organs in the human body and connect specific extremities via blood vessels. If blood does not flow smoothly throughout the body, it will inevitably result in maladies. Massage or pressure with a regular rhythm on the sole will reflect on the organs involved, as it will stimulate the peripheral nerves via the innervation pathways to the central nervous system and spinal nervous system and induce a relaxation effect, causing a state of homeostasis in the body. The design of Smart Massage Tools based on 36 nerve points on the feet is implemented in the manufacture of PCB boards which can be seen in Fig. 3.

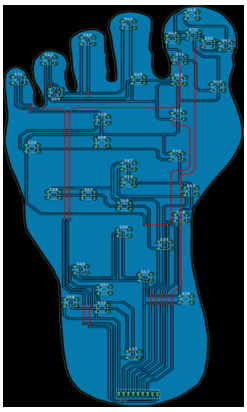

Fig. 3. Foot shape PCB board. Source: personal documents.

The *Smart Massage Tool* was designed as a reflexology tool in the form of an adult's left foot-sized 3D limb with buttons. The buttons represent various nerve points on the sole of the foot and will produce an audio output providing information and an explanation of the specific nerves depending on which button is pressed. The *Smart Massage Tool* is equipped with a 3.5 mm audio port that enables users to listen to the explanations via headphones.

E. Writing the Audio Scripts for the Reflexology Educational Tool

This stage was conducted by referencing the *Buku Ilmu Pijat Pengobatan Refleksi Relaksasi* (Book of Massage: The Medicine for Reflex and Relaxation) published by the Directorate of Vocational Course and Training in 2015, as well as a YouTube video titled "Reflection Points in the Soles of the Feet" presented by the Directorate of Vocational Course and Training. The educational audio script included information on the button numbers, button locations, organ names, and the function of each nerve point.

F. Producing the Nerve Points Educational Audio

This stage was carried out by conducting an audio recording of the script created in the previous stage. Then, audio accuracy correction and editing took place

Fig. 4. Result of the 3D printing. Source: personal documents.

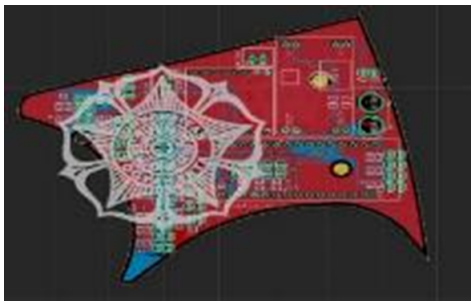

Fig. 5. Layout PCB smart massage tools. Source: personal documents.

using the Adobe Audition software. According to the *Buku Ilmu Pijat Pengobatan Refleksi Relaksasi* (Book of Massage: The Medicine for Reflex and Relaxation) published in 2015 by the Directorate of Vocational Course and Training, there are 36 nerve points in each of the human feet. Nerve points in adjacent locations are combined, reducing the number of nerve point buttons to 29. Without diminishing the information and function of each nerve, adjacent points serve as a single button and audio input.

G. Printing the 3D Design

The 3D design printing stage was carried out at the ICA (Innovation Center for Automotive) at Gadjah Mada University. The type of material chosen for this prototype is TPE (thermoplastic elastomers) filament because it has a soft, smooth texture resembling human skin. The result of the 3D printing can be seen in Fig. 4.

H. Printing the Printed Circuit Board (PCB) Design

Printing the PCB design was carried out using the services of JLCPCB China. This stage is a continuation of the PCB design stage. The process from ordering until the arrival of the PCB in Indonesia took one week. The layout and result of the PCB can be seen in Fig. 5 and Fig. 6.

I. Assembling the Electronic Components

At this stage, the activity commenced with assembling and configuring the Arduino Nano. This was followed by testing out the program to ensure that it could run using the Arduino IDE computer software and then it was followed by entering the audio into the program and testing whether the audio came out when the button was pressed. Arduino Nano is equipped with a buzzer, which was used as an output medium in the form of sound. A sound will be produced when

Fig. 6. Result of the PCB printing. Source: personal documents.

the sensor detects pressure on the product (Rio and Wulansari, 2020).The next stage was assembling the electronic components into the *Smart Massage Tool* prototype when the program was successful.

J. Assembling the Smart Massage Tools Prototype

The printed components were assembled into a fully functional Smart Massage Tool prototype at this stage. When all components of the foot had been properly assembled, the electronic components were then assembled into the prototype according to the pattern of the 3D design.

III. Result

Blind people experience many difficulties in activities including the inability to move without assistance. This makes them dependent and also makes them feel different from normal people. Especially when blind people learn a certain ability, namely reflexology on the feet. Reflexology massage is carried out with basic learning to determine the location of the foot reflexology nerve points. This reflexology ability can become a provision for the expertise of blind people with disabilities. Research has generally innovated tools for the blind in moving [13]. Research by Ozsahin *et al.* [14] (2022), was created a cost-effective ultrasonic vision device. The device has an ultrasonic sensor that measures distance, and a buzzer that beeps when an obstacle is encountered. The availability of the proposed device in bulk would eliminate the using of conventional canes, which are unwieldy with less positive effects [14]. The proposed functionality of the device will help blind people to easily access things, thus improving their quality of life. In contrast to this research, this research makes a tool to assist the visually impaired in studying reflexology massage points on the feet. This tool is based on a microcontroller and pressure sensor.

The design and production of the prototype has been completed 100 percent. The prototype, which is named Smart Massage Tool, is a microcontroller-based smart foot designed as an educational tool for locating reflexology nerve points. Specifications of the Smart Massage Tool include the following prototype size layouts: (a) length of the sole: 248 mm; (c) width of the sole: 89 mm; (c) width of the ankle: 80 mm;

Fig. 7. Measurement of the smart massage tools. Source: personal documents.

(b) width of the leg: 66 mm; (e) height of the leg: 75 mm; and (f) overall height: 150 mm. Moreover, the framework of the Smart Massage Tool prototype is made using a 3D printed 1.75-mm thermoplastic elastomer (TPE) filament. The result of printing 3D can be seen in Fig. 7.

Because the texture is soft and resembles the texture of human skin, the epidermis is cream-colored. Meanwhile, the embedded Arduino Nano serves as the brain of the Smart Massage Tools prototype. Arduino Nano is a microcontroller with an Atmega328 microprocessor that functions as an input and output processor in a data processing circuit, so that it can function in accordance with the device's initial design goals.

The Smart Massage Tool can be used as an educational tool that makes it easier for users to learn the location of nerve points on the soles of the feet and the organs to which these nerves are connected. Because the output of the Smart Massage Tool prototype is in the form of sound, this tool is ideal for visually impaired individuals who wish to study reflexology independently, as well as for use as a teaching tool in institutions that provide reflexology classes. In contrast to research conducted by Al-Hasan *et al.* [15] (2017) that created guide sticks to be used by visually impaired individuals, in which the sticks were imbedded with ultrasonic sensors that channeled waves in order to detect nearby objects. The Smart Massage Tool on the other hand, using of voice recordings stored in the microcontroller, which were then executed by the Arduino IDE program to emit sound when the sensor on the demonstrator's leg was pressed. The pressure sensor in this tool is located on a button that is made very embossed or appears on the surface of the sole of the foot, which is made to be easily touched by the visually impaired and pressed to issue an explanation of the name of the nerve point that the user is studying. This is different from the principle of the tool produced in the research of Wenqiu Liu *et al.* [16] (2023), which is a self-powered tactile Braille typing glove specifically designed to help individuals who are blind and deaf. The gloves feature a self-generating electrical signal, eliminating the need for an external power source. The tool instead uses a low trigger pressure sensor of 20 N, in contrast to smart massage tools that use a higher pressure sensor.

The first step in operating the Smart Massage Tool prototype is to put in a Li-ion battery as the electrical power source for turning it on. The Arduino Nano serves as the system controller and also activates the battery indicator so that it can display the battery's state of charge. When a certain button on the sole of the foot is pressed, the pushed button sends a signal to the Arduino Nano. Then, the DF Player receives instructions from the Arduino Nano to transmit audio files based on the button that was pressed. Then, the speaker emits output in the form of sound, allowing the instrument to emit audio based on the stimulated reflexological nerve points. The components of this tool have similarities with the tool in research by Islam *et al.* [17] (2023) which also uses a microcontroller to detect objects and describe the environment around people with visual disabilities.

IV. Discussion

The Smart Message Tool prototype is a reflexology massage learning tool that meets the requirements of the visually impaired who want to learn and master this profession. It has several advantages, namely that the visually impaired can learn reflexology independently, the product is simple to use, and it provides additional conveniences for the visually impaired because it is equipped with audio indicating the location of nerve points based on guidelines in the *Buku Ilmu Pijat Pengobatan Refleksi Relaksasi* (Book of Massage: The Medicine for Reflex and Relaxation).

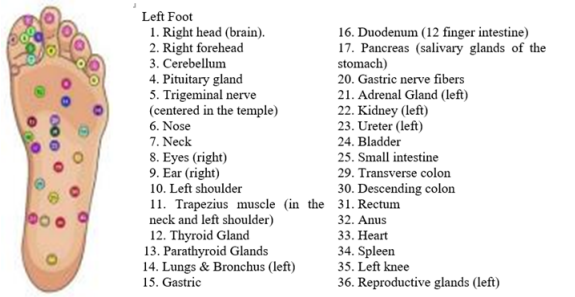

Fig. 8. Nerve points reflexology on the left foot. Source: The Medicine for reflex and relaxation.

In this research, only the left foot was used as a prop. On the sole of the left foot, there are 36 nerve points that can be felt by pressing a small button. The first of these 36 points represents the nerve of the right head (brain), the second represents the nerve of the right forehead, the third represents the nerve of the cerebellum, the fourth represents the nerve of the pituitary gland, etc. When one of these buttons is pressed, a voice will say the name of the correlating body organ and describe the health problem. Even with only sound stimulation, the presence of sound or audio in certain media can enhance the imaginative abilities of the visually impaired (Delani, 2017). According to Suhada *et al.*'s [18] (2018) research, assistive devices

for the visually impaired that contain sensors can detect objects for use.

Fig. 9. Prototype trial for the visually impaired in Yaketunis Yogyakarta. Source: personal documents.

A trial of the first prototype was conducted at the Yaketunis on August 12, 2021, involving three visually impaired individuals. The trial process can be seen in Fig 7. The trial's outcome showed that the prototype was effective. The visually impaired people could use it correctly. They were able to identify the locations of the reflex nerve point buttons. The control buttons can be pressed repeatedly. It is easier for visually impaired individuals who generally hypersensitive to sound to memorize the locations. The existence of audio aids for the blind greatly influences the effectiveness in imparting knowledge to people with visual disabilities [20]. This is very suitable with the concept of making smart massage tools. The Smart Massage Tool can assist users in memorizing the names of the different nerve points in reflexology, are user-friendly and informative, and also allow users to learn and practice reflexology due to the prototype's real-like human foot shape.

The using of microcontroller teaching aids increase the learning motivation and understanding of the students. Students' understanding increased by an average of 90 % after using visual aids compared to without teaching aids which only reached on average of 25 %. That research also showed the fact that 95 % of students are willing to try the material provided themselves when using teaching aids compared to without teaching aids which only reach 10 % [20].

V. Conclusion

This research has successfully created a tool called *Smart Massage Tool* as an educational demonstration foot tool to assist visually impaired individuals in comprehending reflexology massage. The tool can locate the reflexology nerve points on the soles of the feet. This microcontroller-based product is shaped like a real human foot and features nerve-point audio and touchable buttons. When a certain button on the sole is touched, a sound appears, indicating the name of the body organ to which the nerve point is directed. In the final product, there are 36 nerve points. The first nerve point corresponds to the right cranium (brain) organ; the second corresponds to the right forehead organ; the third to the cerebellum organ; the fourth to the pituitary gland organ; and so forth. The nerve points are positioned according to guidelines found in the Sole Zone Reflexology Massage Book, which details the location of nerves in the human foot. *The Smart Massage Tool* is expected to be a solution to the delays in reflexology training caused by the absence of visually impaired-friendly reflexology educational tools. Results from trials of this tool indicated favorable responses from the assessments and responses of several predetermined research participants. For future works, a prototype of a visually impaired-friendly demonstration related to pointing out nerve points for reflexology massage on the hand or back point is needed.

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