DESIGN AND IMPLEMENTATION OF ELECTRONIC EXAMINATION DEVICE FOR IMPROVING THE BLIND STUDENTS’ COMFORT

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Submission date: 20-Sep-2021 11:40AM (UTC+0700)
Submission ID: 1652636931
File name: 16_1_56_2.pdf (213.35K)
Word count: 3218
Character count: 16694

Journal of Engineering Science and Technology
Vol. 16, No. 1 (2021) 807 - 815

DESIGN AND IMPLEMENTATION OF ELECTRONIC EXAMINATION DEVICE FOR IMPROVING THE BLIND STUDENTS' COMFORT

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Abstract

The aim of the research is to design and implement an electronic examination device for helping students while conducting school examinations. The method used is an experimental method including literature study, process design, design implementation, and test the design. The system designed consists of two parts, namely a device for blind students and the exam monitoring application. The student device used Raspberry Pi as a data processor, six push-buttons as braille codes, and five push-buttons as navigation buttons. It is also equipped with a text-to-speech conversion application. The examination monitoring application is functioned to process the registration of the examinees, to process the exam questions, and to record the exam results of the examinees. The results of this research were the examination device and exam monitoring application can function properly. This result can have the effect of improving students' comfort in taking school exams.

Keywords: Blind student, Examination device, Raspberry Pi, Text to speech.

1. Introduction

Student assessment was a mandatory for all students in each school. Test scores were used to measure student achievement during learning process at school [1, 2]. In addition, the purpose of assessment is to provide a feedback for schools and monitor trends in learning. In fact, the implementation of the test was applied to all students including blind students. Nowadays, students conduct tests using computer-based exams that were connected to the server either locally or the internet. Students must have the ability to use computers properly in order to provide answers through computers quickly and correctly. In contrast, blind students have difficulties in operating computers normally due to limitations in vision and difficulty in using a computer keyboard with large numbers of keys. However, several blind people could use a special computer that was assisted with certain software to convert text on a monitor screen to voice.

Voice technologies applications that apply voice interface would be beneficial for blind students [3]. Creators developed an electronic-based examination using a text-to-speech application to assist blind students on exam [4-6]. Stodden et al. [7] mentioned that the use of voice technology in education could improve reading skill blind students effectively. In line with Lucic et al. [8] study, their speech technology-based application successfully gained students enthusiasm in completing the learning task. Even though speech technology had produced a lot of research into learning devices for the blind, however, all of the above research still used common computer device that is not easy to operate by blind people.

The purpose of this research is to design and implement an electronic examination device for blind as solution to their computer-friendly limitations. The method used an experimental method including literature study, process design, design implementation, and test the design. The system designed consists of two parts, namely a device for blind students and the exam monitoring application. The device was consisting of device for student and exam monitoring application for teacher or examiner. The student device must have a text-to-speech application to guide students during exam and push buttons for inputting braille code such as in Hidayat et al. [9] study. The examination monitoring application must be able to record identity and question answers from blind examinee.

2. Method

The system designed was illustrated in Fig. 1. There were three main parts of the system, namely student devices, servers, and routers. First, the student kit consists of Raspberry Pi 3 and eleven push buttons as input (six push buttons for braille code and five push buttons for navigation functions). Secondly, the server was used to record student identity and answer questions. Finally, a router was used to connect between student devices and the server.

2.1. Hardware design

First, Raspberry Pi, is a mini-computer that included in the Single-Board Circuit (SBC) type. It is used in many applications as the main controller. For example, the Raspberry Pi microprocessor is used as a replacement for the PC server to combine the gateway node, database server, and web server [10]. In general, Raspberry Pi was used for monitoring and controlling systems [11, 12]. In other studies, Raspberry Pi is used to help blind people recognize the writing via camera by converting from the image to speech [13, 14]. It already had WiFi embedded in the board so there was no need to add a separate WiFi module. In this research, Raspberry Pi 3 was used as a mini-computer that receives data from push buttons, processes data, sends data to the server computer, receives text questions from the server computer, and converts text documents questions to speech. Braille code from push buttons is processed and converted into letters, numbers, words, or sentences. Each letter or word would be converted to speech for validating that the letters entered correspond with the user entered.

Secondly, the push buttons were used for a combination of braille code as input data and navigation. The order of the buttons was designed according to the order of the braille typewriter buttons to help blind students operate this device properly. The combination of six push buttons (1-6) was connected to the GPIO pins on the Raspberry Pi 3 and placed on the device as shown in Fig. 2. Furthermore, one push button (7) was used as a validation button, which was to validate the braille code combination, two pushbuttons were used for the back (8) and next buttons (9). The user could return to the previous question by pressing the back button or move to the next question by pressing the next button. One push button (10) was used as an enter button, which stores any input data that had passed the previous validation process into an array. Then, one pushbutton (11) was used as a delete button, which erases input data that had been temporarily stored in an array. Thoroughly, the placement of the navigation buttons on the device is shown in Fig. 3.

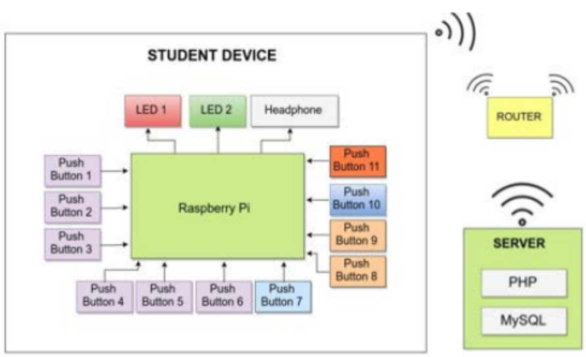

Fig. 1. Block diagram system.

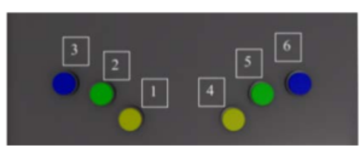

Fig. 2. Braille node combination buttons.

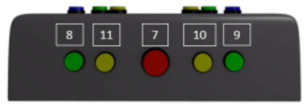

Fig. 3. The navigation buttons.

Third, two LEDs were used for indicators. One LED was an indicator of active or non-active device conditions. It would light up if the device were active and vice versa. Another LED was used for the connection indicator between student's device and computer server. It would light up if the device were connected to the server. These were placed on the front of the device and seen by the teacher or examiner. Lastly, a headphone was used to hear the speech from the device. The speech was questions, instructions, and the spelling of letters or numbers. It is important to use this component in order to make test participants focused on the speech listened.

Another device used in this system was router and server. The router functions as a link between the server computer and students' devices in order to send and receive data. The device was given an IP address class C to connect with each other in the same network. The router used in this study was a wireless router so there was no cable needed for connection. The server computer had an important role in this system. It is a website application that was built using Hypertext Preprocessor (PHP) programming language and used MySQL as a database. It could be used by examiner or teacher to carry out processes as follows: 1) to save the identity of the examinee; 2) to save the answer data sent from the student's device; 3) to write the exam questions with answers; 4) to monitor the process exam; 5) to process the answer data sent from students' devices into information on the results of the exam; and 6) to get exam results.

2.2. Software design

Figure 4 shows the flow diagram on student devices. The explanation of Fig. 4 is as follows: Firstly, (1) the program starts the application, afterward (2) the initialization process was carried out on a number of variables and constants that were needed. Then, (3) the program would run a website welcome speech. Thereafter, (4) the system would request a connection to the server computer. Next, (5) it would validate whether the device is connected to the server or not, otherwise, it would continue to server connection request. After connecting to the server, (6) it would accept test questions from the computer server. Subsequently, (7) it would run procedure to enter name data. Afterward, (8) it ran the procedure to enter the exam identity number, then (9) it processed the procedure to read the questions and enter answers. Every input given by the user would be converted into text by the system. Furthermore, the text would be converted into speech using the text-to-speech application. It used to enter data validation. Finally, (10) the device stored data (identity, answers, and exam numbers) to the database.

2.3. Interface of web application design

This exam monitoring application was developed using a website platform. Previously, users had to register in order to access the program system via the registration page. After registering, users must log in via the login page. If the login process was successful then the user can access the exam monitoring system program. After a successful login process, the system would display a dashboard page that displays the menus in monitoring program. The dashboard application is shown in Fig. 5.

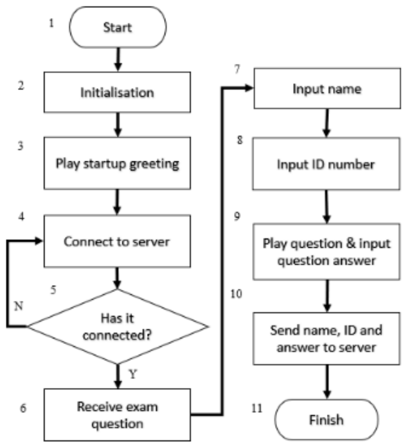

Fig. 4. Flow chart of student device.

3. Results and Discussion

Test of the system was conducted in two main parts, namely test of the students' device and test of the exam monitoring application. Test of students' device was conducted in several steps to test its functionality. Firstly, we tested braille code conversion function. This test aimed to validate the success of the conversion program from the combination of six push buttons into letter and number and convert them to speech. The experiment results indicated 100% successfully (see Table 1). Every letter and number can be detected by system. Additionally, they can be converted to speech correctly. Furthermore, a test of letter combinations conversion for student name. Meanwhile, numbers combinations conversion for student ID into text was conducted to validate the word that inputted by the user. This experiment was successful (see Table 2). Five participant names and IDs can be read correctly.

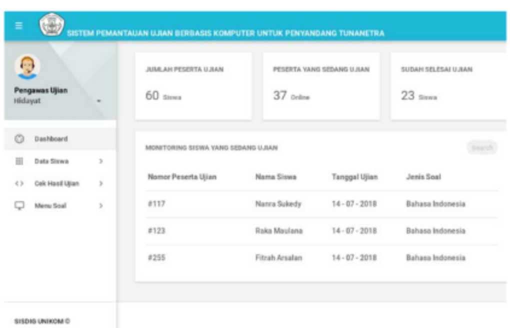

Fig. 5. The dashboard of monitoring application.

Table 1. The results of testing the conversion of braille letters and speech.

Letter	Braille code from buttons	Input data	Convert to letter	Test 1	Test 2	Test 3	Test 4	Test 5	Convert to speech
A/1	○○●○○○	110111	A	√	√	√	√	√	Success
B/2	○●●○○○	100111	B	√	√	√	√	√	Success
C/3	○○●●○○	110011	C	√	√	√	√	√	Success
D/4	○○●●●○	110001	D	√	√	√	√	√	Success
E/5	○○●○●○	110101	E	√	√	√	√	√	Success
F/6	○●●●○○	100011	F	√	√	√	√	√	Success
G/7	○●●●●○	100001	G	√	√	√	√	√	Success
H/8	○●●○●○	100101	H	√	√	√	√	√	Success
I/9	○●○●○○	101011	I	√	√	√	√	√	Success
J/0	○●○●●○	101001	J	√	√	√	√	√	Success
K	●○●○○○	010111	K	√	√	√	√	√	Success
L	●●●○○○	000111	L	√	√	√	√	√	Success
M	●○●●○○	010011	M	√	√	√	√	√	Success
N	●○●●●○	010001	N	√	√	√	√	√	Success
O	●○●○●○	010101	O	√	√	√	√	√	Success
P	●●●●○○	000011	P	√	√	√	√	√	Success
Q	●●●●●○	000001	Q	√	√	√	√	√	Success
R	●●●○●○	000101	R	√	√	√	√	√	Success
S	●●○●○○	001011	S	√	√	√	√	√	Success
T	●●○●●○	001001	T	√	√	√	√	√	Success
U	●○●○○●	010110	U	√	√	√	√	√	Success
V	●●●○○●	000110	V	√	√	√	√	√	Success
W	○●○●●●	101000	W	√	√	√	√	√	Success
X	●○●●○●	010010	X	√	√	√	√	√	Success
Y	●○●●●●	010000	Y	√	√	√	√	√	Success
Z	●○●○●●	010100	Z	√	√	√	√	√	Success
-	●○○○○●	011110	-	√	√	√	√	√	Success

Table 2. Results of testing combinations of letters/ numbers.

No.	Letters/ numbers input	Text combination result	Speech
1	[N, A, N, R, A, -, S, U, K, E, D, Y]	NANRA-SUKEDY	√
2	[A, L, F, A, T, H, -, R, A, J, A, Y, A]	ALFATH-RAJAYA	√
3	[M, U, H, A, M, M, A, D, -, P, E, P, R, A, N, D, I]	MUHAMMAD-PEPRANDI	√
4	[M, U, T, I, A, R, A, -, H, S, B]	MUTIARA-HSB	√
5	[R, I, Z, K, Y, -, A, N, A, N, D, A]	RIZKY-ANANDA	√
6	[1, 0, 2, 1, 4, 1, 1, 7]	10214117	√
7	[1, 0, 2, 1, 4, 1, 1, 8]	10214118	√
8	[5, 0, 3, 2, 3, 7, 8, 0]	50323780	√
9	[2, 0, 1, 1, 4, 7, 8, 2]	20114782	√
10	[3, 0, 7, 9, 9, 5, 4, 2]	30799542	√

Furthermore, a test had been conducted on the conversion of question text and answer options (in *.txt* format) to speech. These question-and-answer options were parsed by the program and converted into speech. The duration time of reading each question is shown in Table 3. The average duration of speech by word was 0.65 s. Speech duration was influenced by the number of characters that compose the word, especially punctuation characters, such as period (.) or comma (,).

Table 3. Reading duration question and answer choices.

Question number	Word number of answer choices	Duration for question (s)	Duration for speech by word (s)
1	8	4	0.50
2	6	3	0.50
3	8	4	0.50
4	4	2	0.50
5	12	8	0.66
6	8	8	1
7	29	16	0.55
8	33	22	0.67
9	25	20	0.8
10	8	7	0.87
			Average = 0.65

Additionally, the black box test on the exam monitoring application was conducted to verify the functions of every part of the application. All parts indicated that the program could function successfully (see Tables 4 and 5). Username form, password form, and enter button could work properly. On the registration page, full name, username, password, password confirmation, email, and contact number form, as well as register button could function properly.

Another test was conducted to verify data on the server. It could store examinees name, ID number, and their answers from student device. Experimental result given in Table 6 has shown that the server could store data entered by the student device correctly.

Table 4. Login page result.

No.	Component Name	Result
1	Username Form	Success
2	Password Form	Success
3	Enter Button	Success

Table 5. Registration page result.

No.	Component Name	Result
1	Nama Lengkap Form	Success
2	Username Form	Success
3	Password Form	Success
4	Konfirmasi Password Form	Success
5	Email Form	Success
6	Nomor HP Form	Success
7	Daftar Button	Success

Table 6. Data storage result.

No.	Data on student device	Data stored on server computer	Result
1	Name: NANRA SUKEDY Examinee No.: 10214117 Answer: A, B, C, B, D	Name: NANRA SUKEDY Examinee No.: 10214117 Answer: A, B, C, B, D	Valid
2	Name: ALFATH RAJAYA Examinee No.: 10214118 Answer: D, A, C, B, A	Name: ALFATH RAJAYA Examinee No.: 10214118 Answer: D, A, C, B, A	Valid
3	Name: MUHAMMAD PEPRANDI Examinee No.: 50323780 Answer: B, C, D, B, A	Name: MUHAMMAD PEPRANDI Examinee No.: 50323780 Answer: B, C, D, B, A	Valid
4	Name: MUTIARA HSB Examinee No.: 20114782 Answer: A, C, D, B, C	Name: MUTIARA HSB Examinee No.: 20114782 Answer: A, C, D, B, C	Valid
5	Name: RIZKY ANANDA Examinee No.: 30799542 Answer: C, B, A, C, D	Name: RIZKY ANANDA Examinee No.: 30799542 Answer: C, B, A, C, D	Valid

All experiment results indicated that the device and exam monitoring application is user friendly and could work properly. The monitoring application could record and show information about students' names, IDs, and answers. We considered that the device designed was very suitable for the use of blind students especially in developing countries. It is because it was built with a mini PC so that the manufacturing price was cheaper and smaller (width 11 cm x height 6 cm x length 18 cm) than an ordinary computer.

4. Conclusion

In conclusion, the exam monitoring application can send and receive data to the student device correctly. Moreover, the server can store entered data successfully. As a result, this electronic is considered as an assistive technology for blind student in conducting the electronic based examination at school, especially in developing countries.

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