



FABRICATION OF FUZZY LOGIC CONTROLLER ON SPEECH LABORATORY SYSTEM USING AT89C2051 MICROCONTROLLER

Abstract

Most colleges and universities in the Philippines consider acquiring a speech laboratory equipment a tough matter to manage due to the prices and after-sales support. Many speech laboratory equipment from abroad exist but would not serve for a long time, particularly in terms of durability and maintainability. The researcher developed a digital innovation in developing speech laboratory equipment that is suitable for the end-user to operate the system quickly using a personal computer (PC) interface connecting serial communication via USB port to a Fuzzy Logic Controller to facilitate the switching of speaker and microphone in the student cubicles/headsets in real audio while in a peer-to-peer communication. Moreover, the monitor or console of the teacher operates in a more comfortable and user-friendly manner. When the teacher clicks the desired function or button, the Fuzzy Logic Controller module will respond and process the command either to enable or disable the student's headset. On the student's side, there is a call button function to highlight the teacher console. Hence, the system is maintainable and flexible that can even run on Windows Operating Systems and Linux.

Index Terms

Digital Innovation, Embedded System, Fabrication, Fuzzy Logic Controller, Microcontroller

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I. INTRODUCTION

The Commission on Higher Education (CHED) [4][13-14] requires a speech laboratory equipment for all colleges and universities that offer Bachelor's degree programs to enhance students' speech and oral communication skills. Many colleges and universities cannot afford to purchase branded equipment because they are expensive [5]. More so, many schools are obtaining a localized speech laboratory which is created by an electronics technician or engineer [7]. Many teachers find it challenging to maneuver the device because of multiple switches and buttons to control [11]. The overuse of these types of devices can easily result in damage [10]. Also, their device cannot provide excellent audio quality.

A lot of speech laboratory equipment purchased abroad are also analog types [11]. The speech teachers find it difficult to control the device because of multiple buttons and switches to control [11]. There are available digitized speech laboratory systems, but they are also expensive and hard to maintain [5]. Schools have difficulty maintaining the equipment as there is no after-sales service [6][8]. Another means of installing a speech laboratory system is to establish an individual computer for each cubicle, which is linked through a networking system with Voice over Internet Protocol (VoIP) setup wherein the server controls every connected computer with software running in the host/server [8]. However, this type of speech laboratory system is also expensive, and most school owners reject it.

For these reasons, the researcher developed a [1] [327-329] Fuzzy Logic Controller to hold in the switching of the audio digitally using a stand-alone microcontroller-based system that caters digital switching on and off of the student's headsets. A desktop computer interface is connected to the computer via a universal serial bus (USB) for easy manipulation by the teacher. Hence, third-party software is needed as a device driver for USB to RS232 converter [12].

On the desktop view, VisualBasic.net was developed to support the connection between the two devices: the desktop PC and the Fuzzy Logic Controller [13]. The audio comes from the microphone input mixer that accepts a coil type microphone inputs feed into the Fuzzy Logic Controller that is held by the instructor [14], and a public address audio amplifier is also required to amplify the audio suitable for multiple headsets installed in the students' cubicles [15]. Fig. 1 shows the conceptual framework of the study.

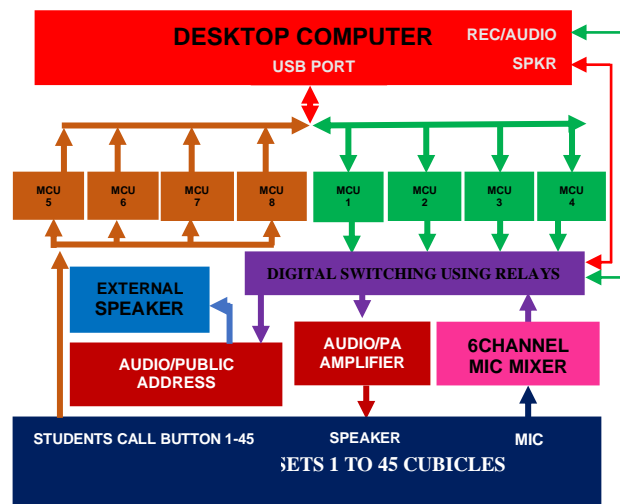


Fig. 1. Conceptual Framework of the study

A. Objectives of the Study

The ultimate objectives of the study are to build another speech laboratory system different from other existing speech laboratory equipment to make it easier and hassle-free for teachers handling speech subjects using PC-Based console that specifies monitor/screen as a console by the teacher for the actual arrangement of the cubicle for the student.

Specifically, this study is focused on the following:

1. Design and Fabrication of a Fuzzy Logic Controller interfaced connected to the desktop computer as the central console to control the students/cubicle headset.
2. Testing its usefulness and adaptability that can keep running in many Windows Operating systems, including Linux.

II. METHODOLOGY

The researcher used the deductive approach in solving a complex query. The Plan-Do-Check-Act (PDCA) criteria were used as a model in finding a solution. After gathering all knowledge from different stages of planning, the researcher scrutinized the data and converted it to facts then postulated to come up with a tangible end-product. Fig. 2 shows the schema of the study.

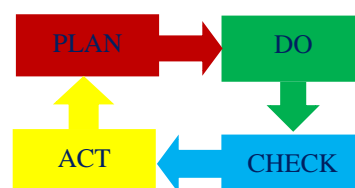


Fig 2. Schema of the Study

B. Design

The researcher used AT89C2051[16], a 2K bytes of memory microcontroller with a twenty-pin version of microcontroller suitable for small or even large applications. There are eight (8) microcontrollers (see Fig. 1) on the main system control panel to facilitate the control switch and call button of the forty-five (45) students or cubicles, which cascades into the serial communication port of each microcontroller [17].

Likewise, there were fifteen (15) information and yield programmable ports in one (1) microcontroller chip. There is a total of sixty (60) programmable ports in four (4) cascaded microcontrollers, namely; MCU1, MCU2, MCU3, MCU4, respectively. Fig. 3 shows the schematic chart of the microcontroller that is related to the hand-off switch. While MCU5, MCU6, MCU7, and MCU8 represent a forty-five call button for the students/cubicle. Fig. 4 shows the circuit diagram of the call button.

Furthermore, in Fig. 3 and Fig. 4, there were only one (1) microcontroller presented because the connection was the same for the other three (3) microcontrollers (See Fig.3), and in Fig. 4 with another three (3) microcontroller with similar connections, including all forty-five (45) relay switches. The Fuzzy Logic Controller system will synchronize the system, according to Fig. 1, presented in the conceptual framework.

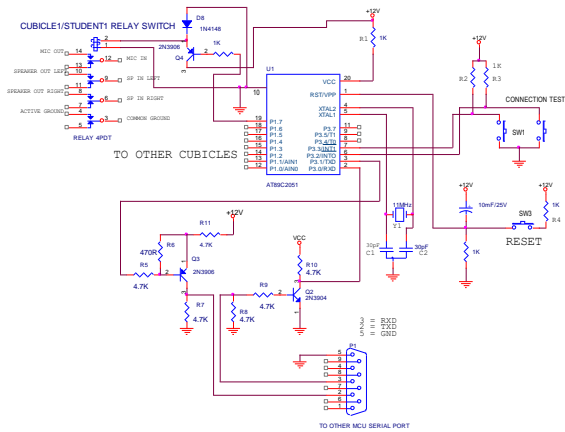


Fig. 3. Fuzzy Logic Controller Circuit Diagram

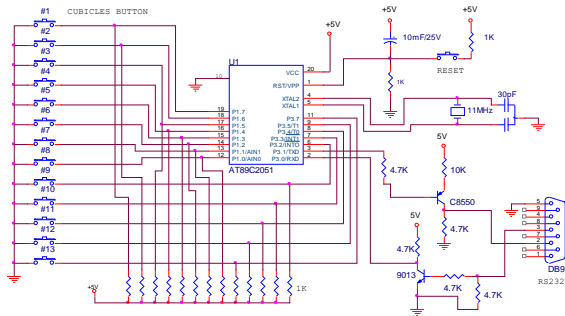


Fig. 4. Call Button Schematic Diagram

C. Relay Switching Module

The researcher separated the module for the digital switching of a Fuzzy Logic Controller by using multiple relays as a digital switch module that activates automatically when the microcontroller or Fuzzy Logic Controller receives serial data that is transmitted by the desktop computer [19]. Then, the teacher clicks the mouse to either enable or disable the button to activate or deactivate the microphone and the speaker of the headset and other all-important function buttons in the speech laboratory. Fig. 5 above depicts the circuit diagram of the digital switching module using a relay in three (3) cubicles only.

Then the teacher clicks the mouse to enable or disable the button to activate or deactivate the microphone and the speaker of the headset and all other essential function buttons in the speech laboratory.

D. Power Supply

The researcher also developed a power supply suitable for the power rating of the entire system. It uses a two-Amperes transformer as the main power supply and a regulator IC to determine the output potential. The power supply module is appropriately designed so that it can withstand prolonged use [20]. It was tested for a long time to determine the integrity of the power supply. Fig. 6 shows the power supply module schematic diagram of the system.

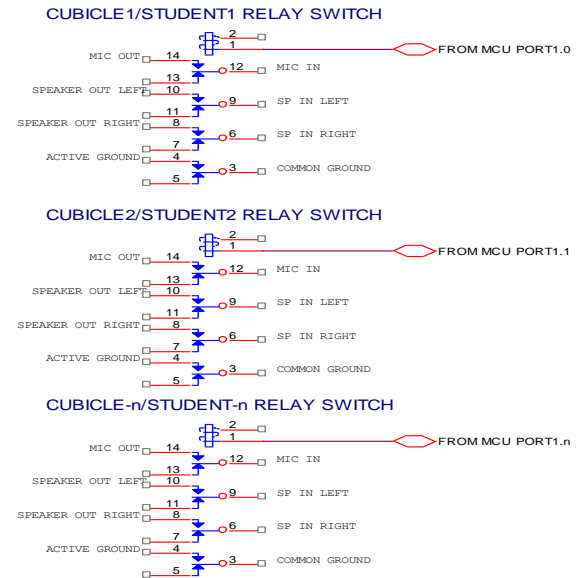


Fig. 5. Digital Switching Using Relay

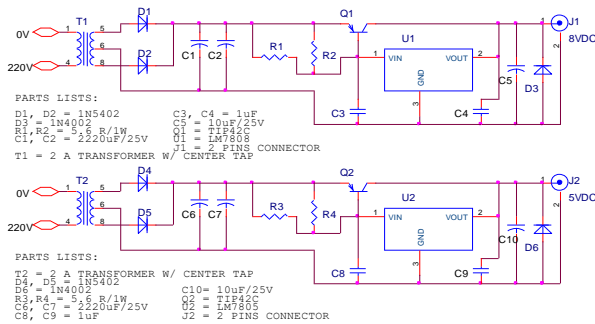


Fig. 6. Power Supply of the Fuzzy Logic Controller

E. Layout

The researcher cited the importance of the PCB layout, wherein it states that [3] Printed Circuit Board (PCB) is the standard name that is used for these electrical sheets. Ever, PCBs were being created by experiencing a confusing technique of point-to-point wiring, and these circuits were profoundly presented to disappointment or harm. After those progressively exact structure strategies were created, they were increasingly secure. More so, the researcher was also determined to use Circuit Wizard software for the PCB layout of the Fuzzy Logic Controller and the power supply module because it was proven to be a user-friendly electronic CAD software after which the researcher did not encounter any difficulty.

After that, the printed circuit board (PCB) was using a single-sided PCB to lessen the complexity [21]. Silkscreen was used to transfer the layout of the printed circuit board finally. Fig. 7, 8, and 9 the PCB layout of the Fuzzy Logic Controller switching relay module and power supply module.

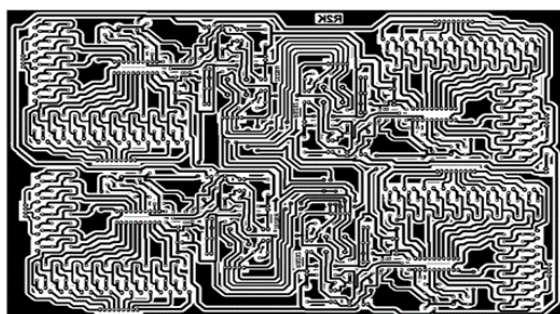


Fig. 7. PCB Layout of the Fuzzy Logic Controller

The size of the PCB layout of the Fuzzy Logic Controller was almost the same as a short bond paper that is larger than the motherboard of a typical desktop computer in which the researcher met many issues in transferring into the printed circuit board (PCB), another layout to the PCB for the relay modules with the same size of the Fuzzy Logic Controller. Fig. 8 shows the layout of the relay module and Fig. 9 power supply module.

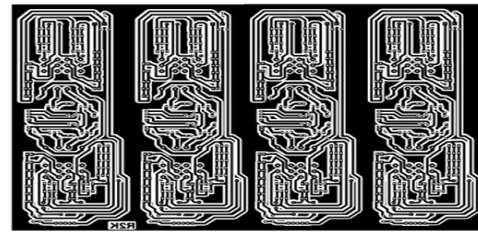


Fig. 8. Layout Relay Module

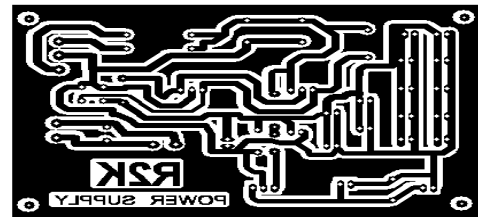


Fig. 9. Layout Power Supply Module

F. Assembly and Fabrication

After creating a Fuzzy Logic Controller PCB, relay switching module PCB and power supply PCB next was placing of parts to the designated part number. They are soldered carefully to avoid contamination to another track that can cause a short-circuit to the system that it may damage the components. Making a front panel and back panel of the Fuzzy Logic Controller using CorelDraw x5 version software, printed in the large sticker and paste to the steel chassis that can be bought in the local electronics store, drilling holes to the desired position of the microphone and a speaker jack for the microphone input and speaker output. Fig. 10 shows the finished product of the Fuzzy Logic Controller device.



Fig. 10. Fuzzy Logic Controller System

G. System Testing

The researchers were careful in testing the functionality of the system in a naked part, without any chassis-mounted so that the troubleshooting can be made quickly before installing it to the final setup of the system. Wiring the entire modules to connect to their desired location was carefully done to the actual chassis for the finalization of the system.

Hence, there were two (2) codes which were created to set up a proper testing process, first, a code for the microcontroller using an assembly language program given by the instruction set of the Intel family microcontroller known as MCS51 instruction sets, a complex code to communicate serially the eight microcontrollers installed in the Fuzzy Logic Controller. Second, codes were made in Visual Basic.net to test the connected part of the two devices if the connection was established before doing the final coding process to finalize the testing procedure. Fig. 11 shows the test form screen for testing purposes only.

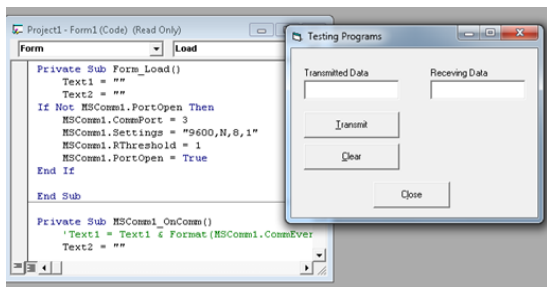


Fig. 11. Testing form screen VB.net Language

Finally, showing the connections of the two (2) devices, the desktop PC and the Fuzzy Logic Controller, the researcher continued to make a code to come upward with the desired end product of the system.

The researcher made several changes in the codes before the functionality was finalized. The device was tested after to note if it works. Fig. 12 shows a receiving code from assembly language at Raisonance IDE (RIDE) environment compiler software.

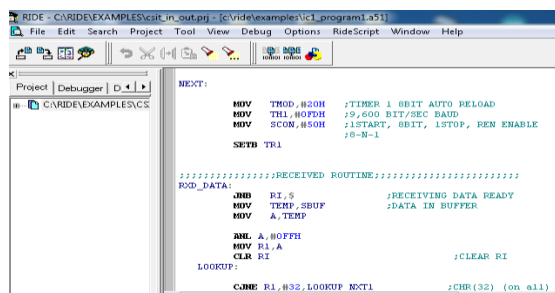


Fig. 12. Receiving Code Embedded in Microcontroller chip

III. RESULTS AND DISCUSSIONS

The researcher finally came up with the desired end-product. Fig. 13 shows how to unfold gradually and how the system is running in the desktop computer as the central controller or console for the teacher to operate a more comfortable and user-friendly system.

When the teacher clicked the desired function, the Fuzzy Logic Controller module will response and process the command, like enabling/disabling the students' headsets. Fig. 14 shows the Fuzzy Logic Controller on Speech Laboratory System Using AT89C2051 Microcontroller that is manipulated by the teacher during operation.



Fig. 13. Main Form Screen of Desktop Computer



Fig. 14. Fuzzy Logic Controller on Speech Laboratory System

The main form or screen of the desktop computer was the console of the teacher wherein the real setup and numbering of the cubicles are shown in the main form monitor or display to locate the places of each student quickly (See Fig. 13). The teacher operates the machine in a user-friendly manner because everything can be manipulated by the mouse, especially the basic operation of the speech laboratory-like listening to the individual student or group or even broadcasting without using a headset. Everything was made by just clicking the mouse in the desired command button. Also, while talking to the students, the teacher can record the conversation

by clicking the RECORD check button to enable audio recording of the computer, saving the conversation, and can be played back as well using surround amplifier or to the selected target student. The student cubicle console is shown in Fig 15. The student cubicle control panel consists of a call button, a mic in, a speaker out and volume control to the headset when the call button is press, the cubicle number of the PC monitor screen was highlighted.



Fig. 15. Student/Cubicle Module



Fig. 16. Fuzzy Logic Speech Laboratory System

Also, the whole system setup was shown in Fig. 16 to visualize the actual Fuzzy Logic Controller on Speech Laboratory System Using AT89C2051 Microcontroller. It was proven and installed in one of the prominent schools/colleges in South Cotabato, particularly in General Santos City.

Speech Laboratory in the Market

At present, there are many existing speech laboratories in the market, but the designs are different because the researcher developed a conventional way of designing a solution. See Fig. 17, Fig. 18, Fig. 19, and Fig. 20, respectively, showing the big difference in its design and presentation of the entire settings. In Fig. 18, the University of Southern Philippines Foundation (USPF) acquired speech laboratory equipment from DY Multimedia Labs last 2005, the setup was PC-Based, almost similar to Fuzzy Logic Controller, but it is compact package proven difficult to repair due to all-in-one package including audio amplifier and microphone mixer. Also, on the main screen of the computer, there were many additional functions included in which the teacher was not comfortable to use, like audio recording to the external cassette tape recorder. (See Fig. 21, Fig. 22, Fig. 23) partially functional but needs to be repaired because of the many issues encountered by the teacher during laboratory operations.



Fig. 17. VoIP Speech Labs



Fig. 18 USPF Speech Labs

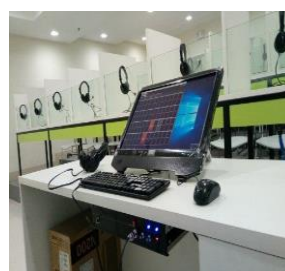


Fig. 19. Fully Computerized



Fig. 20. Analog Speech Labs

It is identified that the Fuzzy Logic Controller can be maintained by IT professionals, as presented in this paper because of the modular approach of developing the system. Another factor that the system is highly maintainable because it is included in the system software with a knowledge-based diagnostic and troubleshooting system when needed during troubleshooting. While the Fuzzy Logic Controller equipped with a diagnostic button to test the communication between the Fuzzy Logic Controller and the desktop computer communication connections.



Fig. 21. Controller



Fig. 22. Teacher Console

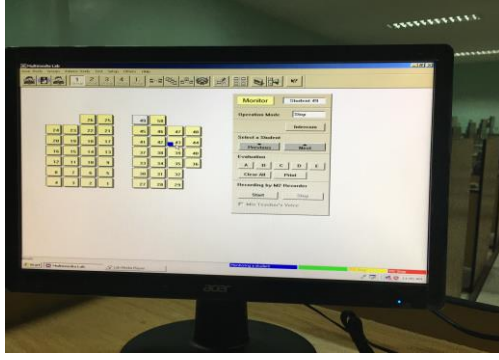


Fig. 23. Main Screen of DY Multimedia Speech Lab

Functionality

During the testing procedure, the researcher cited some studies of testing the compatibility of the operating system [2] that includes the system compatibility of different versions of Windows Operating Systems to test its flexibility. Table 1 shows the tabulated result of the testing process on various versions of the Operating System, including Linux.

In the progress of testing processes, the researcher discovered that the headset needs a protective system circuit to protect the speaker headsets when there is a sudden increase in volume in an audio amplifier setting. Fig. 24 shows the speaker protection circuit diagram installed in the student or cubicle headsets.

Table 1. TESTING ENVIRONMENT COMPATIBILITY

Operating Systems	Compatibility	Functionality
WINDOWS 7	YES	YES
WINDOWS 8.1	YES	YES
WINDOWS 10	YES	YES
LINUX	YES	YES

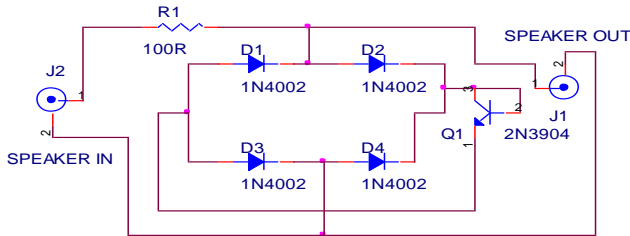


Fig. 24. Speaker Protection Circuit

Another testing procedure conducted to test its peer-to-peer communication capability by using serial communication between PC and Fuzzy Logic Controller during the actual operation of the speech laboratory controller. Table 2 shows the tabulated result.

Table 2. PEER-TO-PEER COMMUNICATION TESTING RESULT BETWEEN PC AND FUZZY LOGIC CONTROLLER UNIT.

No. of Trials	PC main form for Students Cubicle#	Teacher Button ON/OFF	Cubicle No #	MIC Status	Speaker Status
Desktop PC			Fuzzy Logic Controller		
1	1	ON	1	ON	ON
2	1	OFF	1	OFF	OFF
3	2	ON	2	ON	ON
4	2	OFF	2	OFF	OFF
5	3	ON	3	ON	ON
6	3	OFF	3	OFF	OFF
7	4	ON	4	ON	ON
8	4	OFF	4	OFF	OFF
9	5	ON	5	ON	ON
10	5	OFF	5	OFF	OFF

Based on the results of Table 2, there were no errors that were encountered for every clicked on the command button by the teacher during the testing process. Meaning, the communication between desktop PC and Fuzzy Logic Controller was consistent and stable.

To understand further the result of testing, please refer to Fig. 13, the main form/screen of the system that serves as the console of the teacher. In general, the system was designed and ready for prolonged usage of operation without turning OFF the system. In this premise, the researcher knew how to create a functional circuitry in the serial communication controller, wherein it was fully isolated from any noise.

IV. SUMMARY, CONCLUSIONS, RECOMMENDATIONS

Based on the results of the design and fabrication of a Fuzzy Logic Controller of Speech Laboratory System Using AT89C2051 Microcontroller was found to be functional after a thorough testing process using different operating systems. After long hours of testing, the gadget was found to be reliable, durable, and maintainable. In addition, the spare parts are locally available in case a replacement is needed.

Conclusion

The researcher concludes that cascading two or more microcontroller via serial communication ports must follow the basic concepts of Data Communication by sending a valid code or ASCII code serially from point A to point B using synchronous or asynchronous transfer mode. Each microcontroller was programmed and embedded in its memory to perform a specific task. In the case of the Fuzzy Logic Controller, in Fig. 1, the cubicles/students one (1) to thirteen (13) were controlled by MCU1 and MCU5, cubicles fourteen (14) to twenty-six (26) were controlled by MCU2 and MCU6, cubicles twenty-seven (27) to forty (40) were controlled by MCU3 and MCU7, while forty-one (41) to forty-five (45) and other functions like; GROUP, RECORD On/Off, EXTERNAL AUDIO In/Out On/Off controlled by MCU4 and MCU8. Thus, the teacher clicked the command button on the main screen form of the host PC, and the host PC sent a code to a respective MCU's to enable the student/cubicle headset. Therefore, it is a precise application of peer-to-peer communication wherein two (2) computers communicating with each other in a full-duplex mode.

Furthermore, the use of the AT89C2051 microcontroller was an acceptable practice in fabricating complicated applications because of the flexibility and strength of the chips, which can survive for a more extended time depending on the intent of the user.

More so, flexibility in the sense that the I/O port of a microcontroller can be used as input or output. Therefore, the researcher appreciated the performance of the microcontroller in terms of designing and fabricating the Fuzzy Logic Controller on Speech Laboratory System wherein the system was built and functioning correctly after being installed in the laboratory room in the college of Mindanao. This state-of-the-art product was a perfect technopreneur scheme wherein the output of this research finds a sure possible to the product market, particularly for schools.

Recommendations

For the future development and betterment of this study, the researcher recommends the following:

1. Allow a personal display screen/LCD to the cubicles so that the students can view the article that is transmitted by the teacher instead of the big screen installed or centralized display in the speech laboratory room.

2. The provision of a wireless connection of the cubicle/student is possible instead of a wired connection. WIFI connectivity is better and the use

of the Internet of Things for easy installation of the entire system. But there is no guarantee of a long time of usage.

3. Require an RF-ID reader to be installed at the entrance area to enable the automatic console/cubicle/student button on the desktop PC when the student enters the room.

At long last, the arrangement of the Fuzzy Logic Controller of Speech Laboratory System is adaptable that it very well may be balanced and planned dependent on the details or prerequisites of the customer.

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