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Automatic Voice Recorder Designing as A Project-Based Learning Implementation To Enhance Skills In Designing Aeronautical Telecommunications Facilities

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ABSTRACT

Project-Based Learning (PjBL) is a highly engaging active learning model that fosters increased student participation and enhances their problem-solving abilities. Automatic voice recorder design was an output of PjBL undertaken by students in the Air Navigation Engineering diploma four years program, especially in the aviation communication equipment course. One of the learning outcomes of this course is being able to design aviation communication equipment, such as voice recorder. The method used in designing an automatic voice recorder was DDR from Richey and Klein, which consists of design, development and evaluation stages. The results of an automatic voice recorder design trails can be concluded that the design has worked well, but does not fully meet the technical specifications of voice recorder for VHF Air-Ground communication transceiver, including storage capacity, non-interfering playback operations, and accuracy of recording time. The assessment results of the PjBL indicate that all students have successfully attained one of the specified learning outcomes in the aviation communication equipment course, particularly in the area of voice recorder design. This achievement will ultimately contribute to the enhancement of students' skills in designing aeronautical telecommunication facilities.

Keywords: Aeronautical Telecommunication, Automatic Voice Recorder, Project Based Learning

A. INTRODUCTION

Indonesian Aviation Polytechnic, a part of Republic Indonesia Ministry of Transportation, is an educational institution specializing in providing vocational education in the field of aviation. This polytechnic offers several diploma programs, including the Air Navigation Engineering diploma four years program. The learning outcomes of this program is to equip students with the skills to analyse, design and develop the equipment, and effectively identify the root causes of problems based on data, rules, references and procedures to formulate data-driven solutions on the domains of aeronautical telecommunication and aviation electronic facilities. Aeronautical telecommunications facilities are frequently denoted as CNSD. These facilities are regulated by the Civil Aviation Safety Regulations (CASR) Part 69, which defines aeronautical telecommunication facilities, encompassing aviation communication (C), air navigation (N), flight surveillance (S), and data processing (D) equipment. Voice recorder are classified as a subset of aviation communication equipment (Republic Indonesia Ministry of Transportation, 2021).

Regulations within Indonesia require that air traffic control units are equipped with recording equipment capable of documenting both communications and ambient sound conditions within the air traffic control room environment. These recorded data must be retained for a minimum duration of 24 hours (Republic Indonesia Ministry of Transportation, 2017). The functions of a recorder are to record all voice communications between air traffic controllers (ATCs) and aircraft pilots via the Very High Frequency Air to Ground (VHF A/G) communication transceiver, or to record all voice communications between ATCs and other Air Traffic Services (ATS) units in context of air traffic control coordination (DGCA, 2015). Air-Ground communications pertain to interactions between aircraft and ground radio stations, serving as a vital communication tool that facilitates efficient and secure air travel operations. The establishment of communication standards, such as the protocol governing exchanges between aircraft pilots and ATCs using VHF communication systems commonly known as the air band, has further contributed to the effectiveness and safety of these communications (Putra & Suryanegara, 2023).

In a period marked by high youth unemployment, the availability and quality of vocational education play a crucial role. Both policymakers and researchers recognize the significance of vocational education in facilitating the transition from education to the world of work. However, it's important to note that the concept and objectives of vocational education can vary (Fuller, 2015). It is essentially designed to prepare students for the competitive job market and

contribute to addressing unemployment issues in the country (Zarman, 2011). Vocational education, as defined, is a form of education that emphasizes the acquisition of practical skills for the workplace (Suharno et al., 2020). Vocational Education and Training (VET) plays a crucial role in job acquisition, economic strengthening, addressing unemployment, and promoting social inclusion. However, it remains undervalued and suffers from a lack of prestige. VET is frequently perceived as a less appealing educational pathway compared to general education and is often considered a secondary choice for students who are not at the top of their class. It is commonly viewed as an educational route that can lead to swift job placement but not necessarily to well-paying, highly respected positions (Harris & Clayton, 2020). VET graduates are more likely to have disadvantages in literacy skills, advantages in short-term employment, and disadvantages in long-term employment compared to graduates from the general pathway. Significant differences exist between work-based and school-based VET systems regarding their effects on literacy and employment outcomes (Choi et al., 2019).

The nation's VET landscape is characterized by a complex mix of training facilities, managed by a centralized administration that involves multiple agencies and bureaucracies. These entities have coordination responsibilities and resources allocated for VET implementation (Helmy et al., 2021). The challenges of VET in Indonesia are multi-faceted, with issues stemming from policy, internal factors, and a lack of adequate support (Setiyawami, 2021). Some of the specific challenges encountered in the Indonesian include insufficient facilities, a shortage of qualified teachers, and limited industry support (Suharno et al., 2020). Students also face great challenges, both in terms of infrastructure and individual capabilities, with no statistically significant gender-based impact. Practical training mandates the use of distinct materials and tools (Albado et al., 2023).

The evolving demands for cognitive skills in the labour market pose a challenge for graduates of vocational education, necessitating strategies to enhance 21st-century skills within this context. One effective strategy is the implementation of an active learning model, such as Project-Based Learning (PjBL) (Megayanti et al., 2020). The prevalence of PjBL has been on the rise. Research has found a significant relationship between the PjBL method and various aspects, including collaborative learning, mastery of disciplinary subjects, iterative learning, and the attainment of authentic learning experiences. This, in turn, fosters higher levels of student engagement (Almulla, 2020). Almost all students expressed their belief that PjBL was very interesting (Maros et al., 2023). Furthermore, PjBL is recognized as a learning model capable of enhancing student learning outcomes, particularly in science education, and

effectively equipping students with problem-solving skills, including critical thinking (Nurhidayah et al., 2021). Based on these insights, the Air Navigation Engineering diploma four years program has integrated the PjBL model into its curriculum. As part of this approach, a project was assigned that involved designing an automatic voice recorder, which was then tested with a class consist of 24 students.

B. METHOD

The primary objective of this research is to design an Automatic Voice Recorder, as part of the implementation of (PjBL) in the Aviation Communication Facilities course. The aim is to enhance students' skills in designing aeronautical telecommunication equipment. The design process for the Automatic Voice Recorder is structured using a research and development model, which comprises three stages: Design, Development, and Evaluation. Richey and Klein define the Design, Development, and Evaluation (DDR) process as "the systematic study of design, development, and evaluation processes with the goal of establishing an empirical foundation for the creation of instructional and non-instructional products and tools and new or improved models governing their development" (Richey & Klein, 2014).

During the design stage, the designing of the Automatic Voice Recorder block diagram will take place, including the determination of necessary hardware and software components. In the subsequent development stage, the assembly of hardware and the design of software will be executed. Finally, in the evaluation stage, the equipment will be subjected to testing. The primary objective of evaluation is to assess the accomplishment of development objectives (Maydiantoro, 2021). It's important to note that evaluation plays a significant role in the design and development process, particularly in product and tool research. Designers who adopt systems approach typically assess interventions during the development phase. Researchers studying the design and development of products or tools often gather evaluation data to determine their impact on learning (Richey & Klein, 2014). Therefore, to measure the PjBL impact on the learning outcomes, an assessment of the PjBL will be conducted.

C. RESULTS AND DISCUSSIONS

1. Design

The Automatic Voice Recorder is designed to record and store conversations between ATCs and pilots. It functions by taking input from the VHF A/G communication transceiver. The design of this Automatic Voice Recorder is illustrated in Figure 1. The analog audio signal from the VHF A/G communication transceiver is initially received by a USB Sound Card. This

component is responsible for converting the analog signal into a digital format, which is then transmitted to the Raspberry Pi. The Raspberry Pi serves as both an input processing control server and a storage device for the recorded data. The data recorded and stored in the designated folder on the Raspberry Pi can be accessed by a laptop (client) through a computer network based on Wi-Fi, using the Samba Server program. In the user interface section, a Windows-based application, developed using Microsoft Visual Studio, takes directory input from the Raspberry Pi folder. This application presents the recorded data on the laptop screen, making it accessible to the user through the voice recorder application.

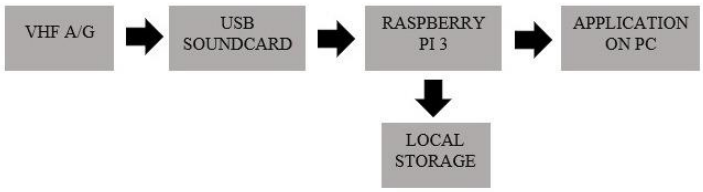


Figure 1. Automatic voice recorder block diagram

The hardware components required for constructing an Automatic Voice Recorder include a Laptop, Toolkit, Multimeter, Box (casing), Bolts, VHF A/G Communication Transceiver, Raspberry Pi, USB Soundcard, Memory Card (SD Card), Audio Cable (jack to jack), Micro-USB Power Supply Cable, and UTP Cable. Specific software required for the setup and operation of the Automatic Voice Recorder includes Microsoft Visual Studio, SD Card Formatter, NOOBS, VNC Viewer, and Samba Server.

2. Development

The first step in this stage involves assembling the hardware, as illustrated in Figure 2. The Automatic Voice Recorder captures audio input from the VHF A/G communication transceiver's output port, which is in the form of a DB15 connector. Specifically, it utilizes pins 14 (headphone) for data transmission and pin 15 (speaker) for data reception. The USB Sound Card takes the analog audio signal from the transceiver, converting it into a digital signal that is then transmitted to the Raspberry Pi. The recorder server, represented by the Raspberry Pi, receives and manages the audio signal from the USB Sound Card. It operates in such a way that when the PTT (press-to-talk) button is pressed, audio signal is received by the recorder system. In contrast, if the PTT button is not pressed, no audio signal is received. Furthermore, the recorder server is responsible for storing the input data on the storage system, which is an SD Card. The recorded data saved in the storage folder can be transmitted to a laptop via a computer

network based on Wi-Fi. This network connection is established through the Samba Server program. The Samba Server serves as a bridge between the laptop and the Raspberry Pi, allowing the folders on the Raspberry Pi to be accessed by the voice recorder application on the laptop.

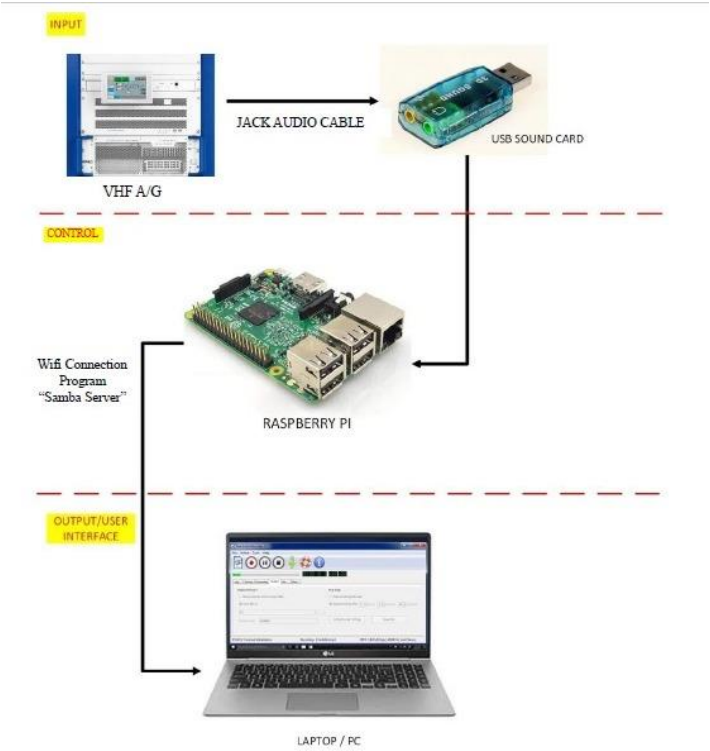
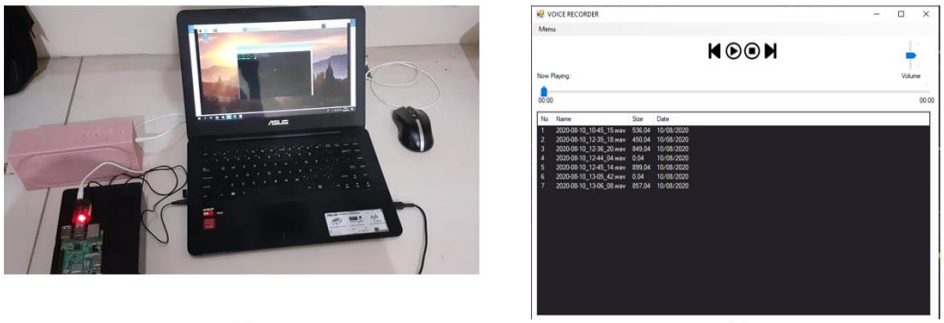


Figure 2. Hardware assembly

The next step is software design, specifically the creation of a Windows-based application. This application is being developed using Microsoft Visual Studio and serves as a user interface for accessing the recorded data. The voice recorder application is structured around two primary pages, namely "Login" and "Home." The "Login" page is the initial page that users encounter when they open the application and wish to access the recorded data. It functions as a secure access point for the recorded data. Once the user successfully enters the password, they gain access to the "Home" page. The "Home" page serves as the operational hub for users seeking to access the recorded data. This page offers several user-accessible features, including a Menu Drive, Volume Up/Down, Time Duration Display, List View, Backward, Forward, Play, Pause, and Stop.

3. Evaluation

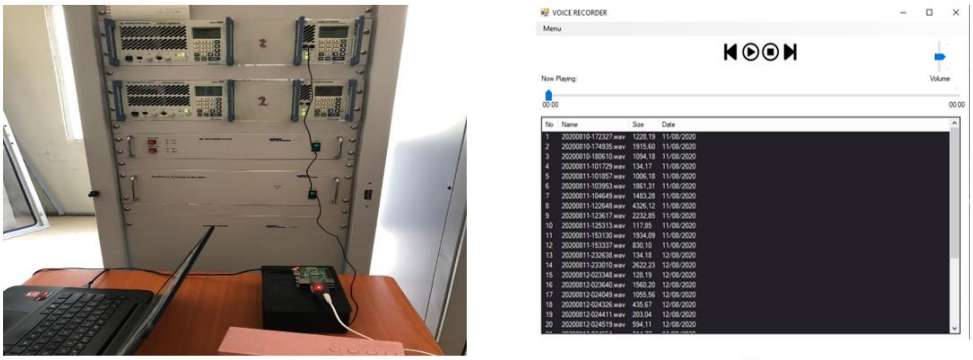
At this stage, trials are being carried out on the automatic voice recorder equipment that has been assembled. The trial is being conducted in three stages. The first stage involves a trial with input from the laptop audio jack, as shown in Figure 3a. This trial model uses music from the laptop as the audio input to be recorded. The mic port on the USB Sound Card is being connected to the audio jack port on the laptop with a jack-to-jack cable. A command file is being executed on the Raspberry Pi system terminal to record the audio. The voice recorder detects audio input, initiating the recording, and it stops recording when the audio input ceases. The recorded data displayed in the list view of the voice recorder application is shown in Figure 3b. It can be concluded that the Automatic Voice Recorder successfully records and stores audio input from the laptop.



(a) (b)

Figure 3. Trial using input form audio jack on the laptop

The second stage, a trial is conducted with audio input from the Rohde Schwarz VHF A/G Receiver headphone port, as shown in Figure 4a. The headphone port is connected to the USB Sound Card's microphone port using a jack-to-jack cable. A command file is executed in the Raspberry Pi system terminal to initiate the recording process. This voice recorder operates automatically. When the PTT (push-to-talk) button on the console desk is pressed, the recorder system begins recording the incoming audio, and when the PTT is released, it stops recording. The recorded data displayed in the list view of the voice recorder application is shown in Figure 4b. It can be concluded that the Automatic Voice Recorder successfully records and stores both the transmitted voice (ATCs) and the received voice (pilots) of VHF A/G communication tranceiver.



(a) (b)

Figure 4. Trial using input form audio jack on the laptop

The third stage is trying to play back the recording results. The procedure for playing back a voice recording involves clicking on the list view, selecting the desired voice recording file, and then clicking the play button. The other playback features in this voice recorder application encompasses pause, stop, backward, forward, volume up, and volume down. The test results for all these features are shown in Table 1.

Table 1. Playback test results

Features	Functions	Test Results
Play	Starts playback of a voice recording	Done
Pause	Pauses playback of a voice recording	Done
Stop	Stops playback of a voice recording	Done
Backward	Backwards playback of a voice recording	Done
Forward	Forwards playback of a voice recording	Done
Volume up	Increase the volume of a voice recording	Done
Volume down	Decrease the volume of a voice recording	Done

4. Assessment of PjBL

Competencies assessed in this PjBL for 24 students include (1) the ability to explain regulations in the field of voice recorder, (2) the ability to explain block diagram of voice recorder, (3) the ability to explain technical specifications of voice recorder, (4) the ability to assemble hardware of voice recorder, (5) the ability to design voice recorder software, and (6) the ability to test voice recorder performance. The results of the assessment of the PjBL are shown in Figure 5. All students are scoring above 70, so it can be concluded that this PjBL has achieved one of the learning outcomes specified in the aviation communication facilities course, namely the ability to design and build aviation communication facilities, particularly in the voice recorder equipment.

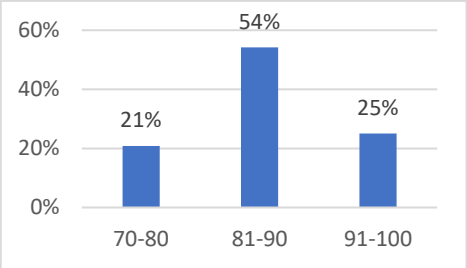


Figure 5. Students score

5. Discussions

The Automatic Voice Recorder utilizes a Raspberry Pi as the recorder's server because it is cost-effective and user-friendly, making it suitable for PjBL. This aligns with prior research that highlights the Raspberry Pi, an efficient and powerful mini-computer with dimensions roughly equivalent to the size of a credit/debit card. The British Raspberry Pi Foundation founded it with the goal of inspiring and empowering a generation of students to be more creative and efficient. Since its launch, numerous open-source communities have contributed to open-source operating systems (OS), applications, and other computing solutions similar to the Raspberry Pi. Furthermore, embedded systems experts and researchers worldwide continually engage in developing innovative projects using these modules, which have demonstrated unique applications (Nayyar & Puri, 2015), (Dipak Ghael et al., 2020). The voice recorder application operates on the Windows operating system. Previous research has concluded that Linux-based operating systems provide an optimal and efficient computing environment for the Raspberry Pi (Saeed et al., 2022). Therefore, in future PjBL, it could be a consideration to develop a Linux-based voice recorder.

The Automatic Voice Recorder is being tested in three stages, namely (1) a trial with audio input from the laptop audio jack, (2) a trial with audio input from the headphone port of the Rohde Schwarz VHF A/G communication Transceiver, and (3) a voice playback trial of recording results. All three trials are going well. The sound quality of the recorded sound is also clear. Factors that influence the quality of voice and speech recordings relate to the choice of hardware, software, microphone, the impact of environmental noise, analog-to-digital conversion, file formats, and acoustic measures resulting from varying levels of signal integrity (Vogel & Morgan, 2009).

This Automatic Voice Recorder does not fully meet the technical requirements for voice recorders for VHF A/G communication transceiver. Some of the technical requirements regarding recorders regulated in MOS 171-02 include (1) recorders capable of recording up to 48 hours without operator intervention, (2) recorders that can store recordings up to 60 days

prior, and (3) playback of recording results must not interfere with the recording process (DGCA, 2015). Tests have not been conducted yet to determine whether this design meets these three technical requirements. The ability to record and store recordings is influenced by the memory capacity of the hardware used, specifically the Raspberry Pi and the Laptop. Additionally, trials have not been carried out to determine the synchronization between the time when the VHF A/G produces audio and the time it is recorded. Playback the recording conversations between ATC and pilots usually occurs during incident or accident investigations. Therefore, the timing of when the sound is recorded is crucial for the success of the investigation. This aligns with previous research, which emphasizes that aircraft accident investigations involve collecting and analysing various data to draw conclusions and make safety recommendations that will prevent aircraft accidents caused by similar factors in the future. Flight recorders serve as an essential data source for successful investigative results (Vidovic et al., 2022). The Flight Data Recorder contains information regarding the current status and performance of the aircraft and its avionics equipment, providing vital data for subsequent investigative actions (Mani, 2018).

D. CONCLUSIONS

The Automatic Voice Recorder design is the output of PjBL undertaken by students of the Air Navigation Engineering diploma four years program in the aviation communication facilities course. This design is functioning effectively, but it doesn't fully meet the technical specifications required for voice recorders used in VHF A/G communication transceiver. These specifications include storage capacity, non-interfering playback operations, and accuracy of recording time. The assessment of the PjBL results indicates that all 24 students have achieved one of the specified learning outcomes in the aviation communication facilities course, particularly in the area of voice recorder equipment. Consequently, by attaining these learning outcomes, the implementation of PjBL is expected to enhance their skills in designing Aeronautical Telecommunication facilities.

E. ACKNOWLEDGEMENTS

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