DEVELOPMENT OF SMART ANSWERING DEVICE FOR EXAM AND QUIZZES BY USING ARDUINO MEGA 2560

NG CHIN HUAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF SMART ANSWERING DEVICE FOR EXAM AND QUIZZES BY USING ARDUINO MEGA 2560

NG CHIN HUAN

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Computer Engineering Technology (Computer Systems) with Honours

Faculty of Electronics and Computer Technology and Engineering
Universiti Teknikal Malaysia Melaka

2025

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI DAN KEJURUTERAAN ELEKTRONIK DAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DEVELOPMENT OF SMART ANSWERING DEVICE FOR EXAM AND QUIZZES BY USING ARDUINO MEGA 2560

Sesi Pengajian : 2024/2025

Saya NG CHIN HUAN mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐ **SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐ **TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.
☑ **TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS) (COP DAN TANDATANGAN PENYELIA)

Alamat Tetap: .....
.....
.....
.....
.....

Tarikh : 01 Januari 2025 Tarikh : 24 Januari 2025

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this project report entitled “DEVELOPMENT OF SMART ANSWERING DEVICE FOR EXAM AND QUIZZES BY USING ARDUINO MEGA 2560” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Student Name : NG CHIN HUAN

Date : 1/1/2025

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer Engineering Technology (Computer Systems) with Honours

Signature :

Supervisor Name : MA TIEN CHOON

Date : 24/1/2025

Signature :

Co-Supervisor :

Date :

DEDICATION

To my beloved mother, Chong Siew Lay, and father, Ng Kok Hong,

and

To my loving family.

ABSTRACT

The Smart Answering Device project aims to develop an eco-friendly and efficient alternative to traditional paper-based exams, addressing both environmental concerns and the challenges of academic dishonesty in online assessments. Utilizing the Arduino Mega 2560 microcontroller, the device incorporates input components such as push buttons and a PS/2 keyboard, and output components including a I2C LCD 20x4, ISD1820 voice/audio record and playback module, buzzer module and LEDs. An android application named Smart Exam App was developed using Android Studio for lecturers to administer the exams. A HC-05 Bluetooth module is used for data transmission between Arduino and Smart Exam App. The system is designed to display exam questions, capture student responses, and provide immediate feedback through an automatic grading system. All the data that are retrieved from the exam can be stored to a lightweight SQLite database. Lastly, lecturer can use PyCharm to generate an excel file, histogram and bell curve graph for further analysis. This project not only aims to reduce paper consumption and associated environmental impacts but also seeks to enhance the integrity and efficiency of exam administration in educational settings. When talked about potential for commercialization, its large-scale adoption could transform education, stimulate economic growth, and create jobs in the technology sector. Integration with an Android app, data analytics, and strategic partnerships boost the device's adoption and drive educational technology advancements. Future work will focus on the AI integration for automated grading, enhanced display and data analytics, and lastly improved connectivity and security.

ABSTRAK

Projek Smart Answering Device bertujuan untuk membangunkan alternatif yang mesra alam dan efisien kepada peperiksaan berasaskan kertas tradisional, dengan menangani kebimbangan alam sekitar dan cabaran ketidakjujuran akademik dalam penilaian dalam talian. Menggunakan mikrokontroler Arduino Mega 2560, peranti ini menggabungkan komponen input seperti butang tekan dan papan kekunci PS/2, serta komponen output termasuk paparan LCD I2C 20x4, modul rakaman dan main semula suara/audio ISD1820, modul buzzer, dan LED. Aplikasi Android yang dinamakan Smart Exam App telah dibangunkan menggunakan Android Studio untuk pensyarah menguruskan peperiksaan. Modul Bluetooth HC-05 digunakan untuk penghantaran data antara Arduino dan Smart Exam App. Sistem ini direka untuk memaparkan soalan peperiksaan, menangkap jawapan pelajar, dan memberikan maklum balas segera melalui sistem pemarkahan automatik. Semua data yang diperoleh daripada peperiksaan boleh disimpan dalam pangkalan data SQLite yang ringan. Akhir sekali, pensyarah boleh menggunakan PyCharm untuk menghasilkan fail Excel, histogram, dan juga graf lengkung loceng untuk analisis lanjut. Projek ini bukan sahaja bertujuan mengurangkan penggunaan kertas dan kesan alam sekitar yang berkaitan, tetapi juga untuk meningkatkan integriti dan kecekapan pengurusan peperiksaan dalam persekitaran pendidikan. Dari segi potensi pengkomersialan, penggunaannya secara besar-besaran boleh mengubah pendidikan, merangsang pertumbuhan ekonomi, dan mewujudkan pekerjaan dalam sektor teknologi. Integrasi dengan aplikasi Android, analitik data, dan kerjasama strategik meningkatkan penerimaan peranti ini dan memacu kemajuan teknologi pendidikan. Kerja masa depan akan memberi tumpuan kepada integrasi AI untuk pemarkahan automatik, paparan dan analitik data yang dipertingkatkan, serta penambahbaikan dalam sambungan dan keselamatan.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Ma Tien Choon for his precious guidance, words of wisdom and patient throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) and my family for the financial support through this journey which enables me to accomplish the project. Not forgetting my fellow colleague for the willingness of sharing his thoughts and ideas regarding the project.

My highest appreciation goes to my parents, parents' in-law, and family members for their love and prayer during the period of my study.

Finally, I would like to thank all the staffs at the UTeM, fellow colleagues and classmates, the faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

TABLE OF CONTENTS

LIST OF TABLES

TABLE **TITLE** **PAGE**

LIST OF FIGURES

FIGURE **TITLE** **PAGE**

LIST OF SYMBOLS

%	-	Percent
Ω	-	Ohm

LIST OF ABBREVIATIONS

ChatGPT	-	Chat Generative Pre-trained Transformer
AI	-	Artificial Intelligence
GHG	-	Greenhouse gas
CO2	-	Carbon dioxide
GtCO2	-	Gigatons of carbon dioxide
REDD	-	Reducing Emissions from Deforestation and Forest Degradation
COVID-19	-	Coronavirus disease 2019
E-learning	-	electronic learning
E-exams	-	electronic exams
E-cheating	-	electronic cheating
ROM	-	Read-Only Memory
CPU	-	Central Processing Unit
ALU	-	Arithmetic Logic Unit
I/O	-	Input/Output
RAM	-	Random Access Memory
AVR	-	Alf-Egil Bogen Vegard Wollan RISC microcontroller
RISC	-	Reduced Instruction Set Computing
PIC	-	Peripheral Interface Controller
ADCs	-	Analog-to-Digital Converters
DACs	-	Digital-to-Analog Converters
UART	-	Universal Asynchronous Receiver-Transmitter
CAN	-	Controller Area Network
SPI	-	Serial Peripheral Interface
IDE	-	Integrated Development Environment
USB	-	Universal Serial Bus
PWM	-	Pulse Width Modulation
SRAM	-	Static Random-Access Memory
KB	-	Kilobytes
MHz	-	Megahertz
OOP	-	Object-Oriented Programming
STL	-	Standard Template Library
ADT	-	Android Development Tools
API	-	Application Programming Interface
GHz	-	Gigahertz
TFT LCD	-	Thin-Film Transistor Liquid Crystal Display
LEDs	-	Light-Emitting Diodes
SDK	-	Software Development Kit
I2C	-	Inter-Integrated Circuit
SDA	-	Serial Data
SCL	-	Serial Clock
VCC	-	Voltage Common Collector
GND	-	Ground
LCD	-	Liquid Crystal Display
I2C	-	Inter-Integrated Circuit

FT	-	Feed Through pin
P-L	-	Play Level-triggered pin
P-E	-	Play Edge-triggered pin
REC	-	Record pin
SPP	-	Serial Port Profile

LIST OF APPENDICES

APPENDIX **TITLE** **PAGE**

CHAPTER 1

INTRODUCTION

1.1 Background

Henry Fischel, an American entrepreneur, invented exams in the late 1800s. China was the first nation to adopt the idea of exams and held the first examination, which is the Imperial Examination. Exams are widely employed in today's society to determine an individual's level of understanding of a certain subject. On the other hand, paper has became the major component in order to make sure an exam can be successfully conduct, leading to a consistent increase in demand for new paper. Paper industries fulfill this demand for new papers sourced from publishers, necessitating the use of wooden pulp, which in turn results in deforestation Therefore, the paper companies are accountable for the continued loss of forest cover, which has an effect on the climate and the ecosystem. Moreover, the paper industries also have an impact on the climate and environment. These industries cause various forms of pollution by releasing hazardous gases into the atmosphere. [1]

Efforts by education professionals to transition from traditional exam methods to more environmentally sustainable and efficient alternatives are underway. Online platforms for exam administration have emerged as one such solution. However, challenges persist due to dishonesty and malpractice among students since every student is using their own device such as laptop that contain many sources of information that is prohibited for exam. Further

compromising exam integrity is the widespread use of AI helpers like ChatGPT, which make it easy for students to find answers with minimal effort.

In order to address these challenges, there is a need to transform the traditional paper-based examination method into a technological advancement system, at the same time preserving its original features. Ultimately, it will help our country with the effort to expand our market in the field of technology engineering.

1.2 Global Issues

Global climate change is closely linked to the issue of deforestation issue, driven in part by industries such as the paper production industry. A great deal of congressional and international discussion and negotiation has resulted from the growing and pervasive worry over global climate change.

In Malaysia's education system, the traditional method of administering exams heavily relies on paper-based assessments, resulting in significant environmental consequences. Efforts to mitigate climate change have primarily centered on reducing greenhouse gas (GHG) emissions, with a particular focus on carbon dioxide (CO2). Deforestation stands out as a significant contributor to CO2 emissions. Thus, efforts to reduce deforestation are regarded as among the most cost-effective strategies for addressing climate change. [2]

Forest, in their natural form, serve as reservoirs for carbon, storing more carbon than they emit. In addition to releasing oxygen, trees collect CO2 and transform it into leaves, stems and roots. More than 25% of the planet's land surface is made up of forests, which also store around 40% of the carbon in soil and more than 75% of the carbon in terrestrial plants. A portion of the carbon stored in destroyed forests is released into the atmosphere either immediately through burning or slowly through decay. According to one estimate, deforestation contributes to land use change, which releases roughly 5.9 GtCO2 (gigatons, or billion metric tons of CO2) annually, or roughly 17% of all human GHG emissions.2. Congress and international organizations are currently deliberating on multiple strategies aimed at curbing carbon emissions resulting from deforestation and forest degradation, commonly known as REDD. [2]

Addressing this global issue requires a concerted effort to transition from paper-based exam practices to more sustainable alternatives. By reducing paper consumption, promoting digital solutions, and implementing eco-friendly exam administration methods, stakeholders can contribute to mitigating deforestation, reducing GHG emissions and combating climate change. Collaborative initiatives involving educators, policymakers and environmental advocates are essential for effecting meaningful change and fostering a more sustainable approach to education worldwide.

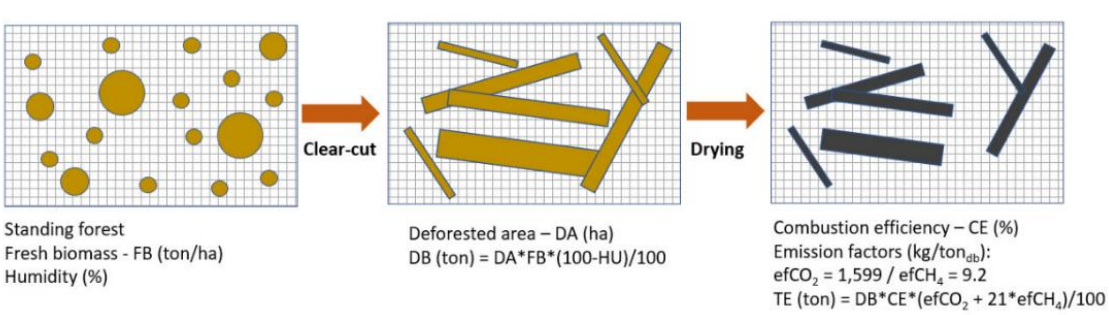


Figure 1.1 The process for estimating emissions of greenhouse gases (GHGs). TE stands for total emissions, DB for dry biomass, and HU for humidity. [3]

1.3 Problem Statement

This traditional method more depends on paper-based examination thereby there are some environmental impacts occur. Exams are likely to degrade the environment due to the use of paper, since the paper industries need a significant numbers of wood pulp in paper production, leading to deforestation. However, what has not been considered is that the emissions produced by the paper industry add to global warming and hence there is a need for an eco-friendly option. Additionaly, the use of paper to conduct exam will ultimately cause subtantial waste generation this is due to all the printed material made by paper will be discarded after single use. With the effects of climate change being worse off recently, there is accruing concern for adopting more green and sustainable pro-approaches for the administration of examinations.

In order to address these issues, the following have been put forward as solutions to replace the typical paper based examination method. One solution that has been proposed by R. Rifin et al which is the development and integration of an Android-Based examination is one of the noteworthy options offered to solve the drawbacks of paper based examination[4]. On the other hand, an electronic educational quiz board was suggested by Zakiah Mohd Yusoff, R SSH, et al for the purpose of testing students' comprehension on Laplace Transform of electrical circuit modeling[5]. In the work of Arman Hadi Azhar, Maslin Sirajudeen, Ahmad Abdul Jalil and Nurul Farhana Low Abdullah the authors described the development of the electronic educational quiz board designed for high school students

focused on the teaching of mathematical transformations[6]. Similarly, The conceptual knowledge of engineering students regarding resistor ideas in electrical circuits was introduced by the establishment of an electronic quiz board proposed by Amar Faiz Zainal Abidin[7]. Nonetheless, some issues and limitations can also be noted in these projects despite being relatively well developed.

The disadvantage of conduction online-based exam is the risk of academic dishonesty since student can easily access to resources that is prohibited in the traditional exam method. The issue of academic dishonesty persists, as students can easily access prohibited information using their personal devices such as mobile, tablet or labtop during exams. It's probable that these actions have an impact on learning in addition to the problem of academic integrity since the research by Brothen and Wambach (2001) illustrates that when students refer to external sources during quizzes. Potentially reduced study efforts since students plan to use theirs notes during the exams (Agarwal & Roediger, 2011)[8]. We aimed to mitigate the adoption of counterproductive study habits. The availability of AI assistants further exacerbates this problem, allowing students to obtain answers with minimal effort and compromising the validity of assessment results. Additionally, concerns about data privacy and security in online exam platforms continue to be significant barriers to widespread adoption.

Though the quiz board may be as useful in ascertaining the degree of understanding of a particular topic, it may not adequately provide for questions that are usually pie in the middle, multiple choice and comprehensive questions regularly posed in examinations and quizzes in varied fields. This limitation cancels its effectiveness in evaluating such aspects of cognition as higher thinking skills or creativity. One of the ideas of the implementation of

the proposed project require user to use components that are not familiar for some students for example female pin headers and also Cartesian coordinate system. Thus, this paper notes that students that are unfamiliar with the digital design interface may face difficulty using this conception. Although these solutions are useful contributions to learning assessment, more has to be done in tackling these challenges and at the same time improve the efficiency of thes solutions.

1.4 Project Objective

The objectives of this project are as follows:

a) To develop a Smart Answering Device utilizing Arduino Mega 2560 capable of answering objective questions and incorporating a grading system.

b) To integrate Arduino Mega 2560 with ps/2 keyboard for answering subjective questions and create an Android application for data collection and display.

c) To analyze the performance of the answering device focusing on grading system accuracy, response time and data transmission reliability.

1.5 Scope of Project

The scope of this project are as follows:

a) Designing and developing a smart answering device for exam and quizzes that can answer both objective and subjective question.

b) Demonstrating the simulation of the exams machine using Tinkercad, at the same time improve, modify and add feature to improve my C++ coding for my arduino.

c) Selecting components suitable for integration with the Arduino Mega 2560 core, considering brand compatibility and functionality requirements for the project.

d) Testing and debugging the exams machine thoroughly after assembly to ensure it functions properly and surpasses project requirements.

e) Soliciting user feedback and iterating on the device's design and functionality based on testing results and user requirements.

f) Documenting the project's hardware and software designs, programming code, and any pertinent information for future reference and replication.

g) Targeting the smart answering device towards educational institutions to bolster the technology and engineering industries. Strong institutional support can foster increased resources for research and development (R&D), leading to greater innovation in technology and engineering.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is a comprehensive analysis of existing research and scholarship within a specific subject or research question. This chapter presents a review of studies related to the development of a Microcontroller-Based Smart Answering Device, which include past research and relevant projects. The literature review will explore key themes such as the evolution of examination methods, the environmental impact of traditional paper-based exams, challenges in digital exam platforms and emerging technologies in examination administration. Through this review, important discoveries and ideas from earlier research will be compiled in this review to provide context for the current study and contribute to the understanding of the topic at hand.

2.2 Traditional Exam Administration Methods

2.2.1 Paper-Based Exams

The history of paper-based examinations dates back over 1000 years, with origins in China where written examinations were developed as part of the Imperial Civil Service promotions system. Despite technological advancements, this ancient form of assessment persists, with many secondary school students in the 21st century still participating in paper-

based exams. This method, characterized by students sitting in rows and writing for extended periods, remains a common practice. Paper-based exams predominantly measure memorization and recall rather than higher-order thinking skills, problem-solving and collaboration. While some proponents highlight the benefits of paper-based assessments, there is a growing call for assessment methods that foster knowledge construction, real-life problem application and active participation [9].

Figure 2.1 Chinese Imperial Examination

2.2.2 Environmental Impact of Paper-Based Exams

Paper plays a crucial role in our lives, intersecting with numerous activities and industries. This extensive usage has fueled rapid growth in the pulp and paper industry. Global paper and paperboard production and consumption in 2008 were estimated to be 389,237 and 388,715 million tons, respectively. Based on the global forest map developed in partnership with Google, Malaysia has the greatest global rate of forest loss between 2000

and 2012. Malaysia lost 14.4% of its forest cover since 2000, covering an area larger than country such as Denmark. As the primary raw material for paper is wood, meeting the growing demand necessitates substantial logging, predominantly from forests. This reliance on forest-sourced wood for paper production inevitably leads to continuous deforestation.

The paper industry's massive deforestation has detrimental effects on the environment. The loss of rainforest areas contributes to seasonal droughts, increased flooding and intensifies global warming, leading to drastic climate changes. These climate alterations result in rising sea levels, agricultural failures and threaten the survival of various flora and fauna species unable to adapt. Other immediate effects of these environmental changes include the deterioration of ecosystems and the introduction of new illnesses[10]. To mitigate these impacts, it is imperative to reduce paper production by shifting high-demand paper-based activities to more technological and electronic methods. Shifting to these sustainable sources can reduce the dependency on forest wood and help prevent further deforestation, thereby protecting ecosystems and mitigating climate change effects.

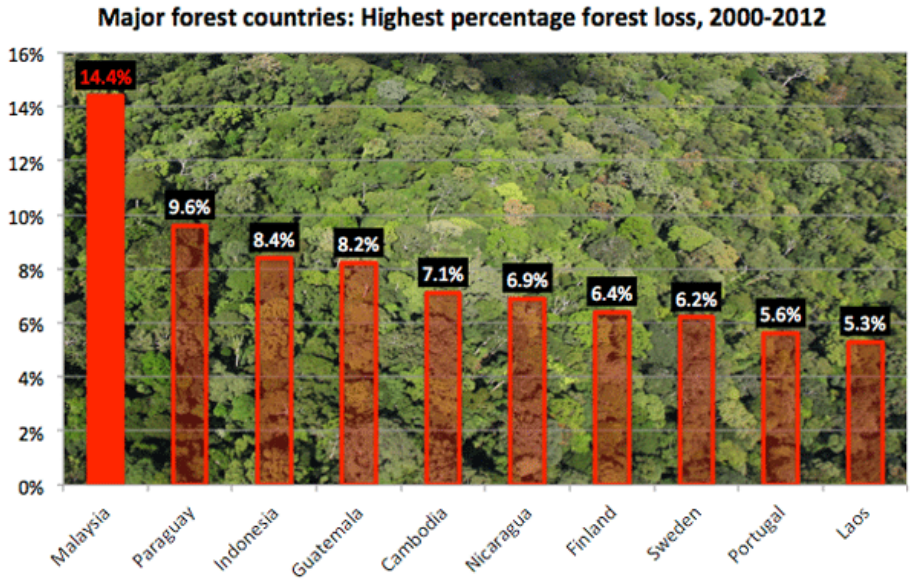


Figure 2.2 Malaysia had the world's highest rate of forest loss between 2000 and 2012.

2.3 Historical Review of Examinations

2.3.1 Assessment 1.0

Fundamentally, assessment 1.0 is the process of obtaining proof of student learning and then analyzing that proof. Features of Assessment 1.0, spanning from the early 20th century to the present day, include predominantly paper-based formats and primarily conducted within classroom settings. These assessments are characterized by formalized administration procedures, high levels of synchronization in terms of timing and location and strict control over content and grading criteria. Remarkably, these characteristics have remained largely unchanged over the decades.

This assessment system has historically functioned effectively. Its highly centralized, top-down nature aligned with the societal structures. The stability of the system has maintained national qualifications as the primary means of staff employment and advancement to the next level of education. Since this system do not change much over the years, it is easily understood by its users, who include educators, parents and students[11].

2.3.2 Assessment 2.0

Evaluation 2.0 presents a new paradigm of evaluation, particularly suited to the digital native, characterized by several distinctive features. Ideally, assessments under this framework exhibit authenticity by incorporating real-world knowledge and abilities. They are customized, meeting each student's unique knowledge, abilities and interests. Evidence

for such a task could manifest in a more digital shape and come in variety of forms such as audio recording, video recordings and email.

However, Assessment 2.0 also presents challenges. Elderly students, also referred to as "digital immigrants," might not regularly use Web 2.0 services and might not have the abilities and mindset needed to participate effectively. Teachers may find it difficult to comprehend and evaluate student work created with these tools because they are primarily digital immigrants themselves. Authentication of individual work in the collaborative digital environment also poses challenges for awarding bodies, due to the volume of digital evidence and collaborative inputs that make the process more difficult[11].

Figure 2.3 Assessment 2.0[11]

2.3.3 The Rise of Online Exam

Online assessments are more challenging than traditional assessments and are referred to as web-based or intranet assessments. For instructors, web-supported applications in the online assessment process provide various benefits. For instance, it is simple to provide comments and to record student responses in a digital file. Student responses are comparable. It is possible to calculate accurate and erroneous answers statistically. Additional benefits of online tests include the ability to administer exams from a single location and require less paper. Multiple-choice, fill-in-the-blank, matching, short answer and right or wrong are some types of questions that can all be utilized in online examinations[12].

E-exams, a crucial component of E-learning, have become an integral part of modern education systems. According to analysis, the conduction of online exams expanded dramatically over the past few decades. With the outbreak of the COVID-19 pandemic, online exams turn into top choices among the institutions all around the globe to act as a replacement of the conventional exam method. Although online exams provide advantages such as convenience, there are drawbacks that need to be addressed to maintain academic integrity.

2.3.4 E-Cheating

In the way to transform conventional method into online-based method, students are presented with both opportunities and risks concerning academic integrity. Since e-exams minimize one-on-one teacher-student interactions, students can use different forms of cheating including accessing notes or other prohibited study materials or exchanging answers with other students without the monitor's notice. Thus, the integrity of the

assessment processes through online platforms become more questionable, which requires active countermeasures against e-cheating.

One of the critical issues in the higher learning institution is the occurrence of e-cheating, whereby students can earn an outstanding mark effortless. When students get credit that does not distinguish their understanding or critical talents, then this problem in the future harms the credibility of the institution. A culture of cheating once developed can spread among students, ultimately cause students to think that cheating is the only way to gain success in their study or even their future work [13]. This kind of issue had to be identified and addressed as soon as possible in order to ensure that such behavior is stamped out.

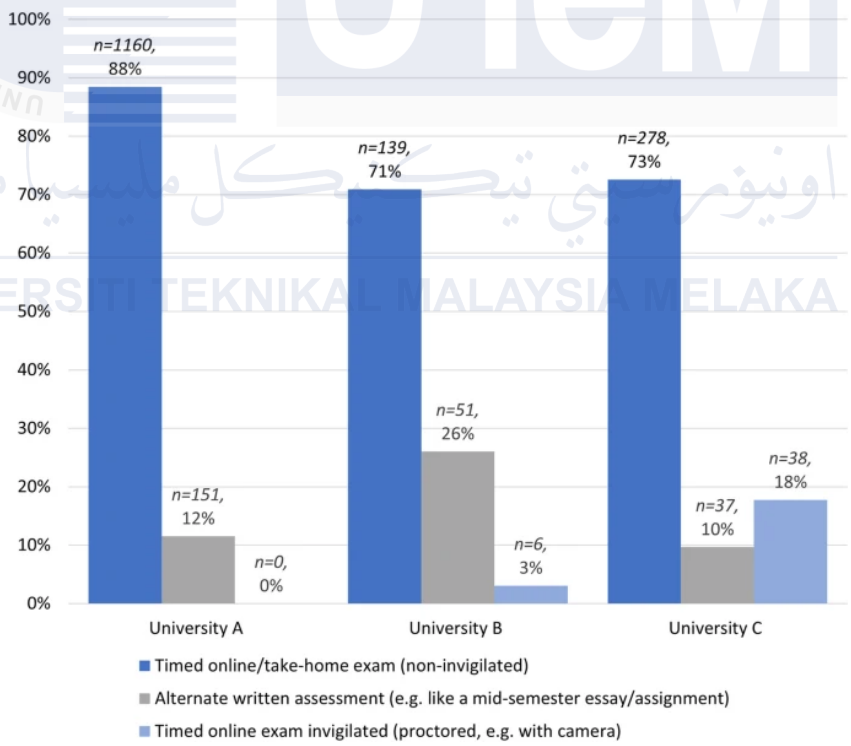


Figure 2.4 Academic Integrity in The Transition to Online Exams

2.3.5 More Challenges and Drawbacks of Online Exams

The social issue of E-learning expansion can be said to have both advantages and disadvantages, specifically the online examination. Online exams aim to produce a fair assessment of students' achievement. However, there are several challenges in the e-learning context concerning the coordination and scheduling of online exams. Online exams are typically conducted using online platforms such as Webex, Microsoft Teams or even the simplest google form, where the student and teacher do not have to be in the same room once the exam is held. A major hindrance is the identification of examinees, this turns out to be a difficult process in the case that without continuing monitor. Also, sometimes it is difficult to guarantee that every student has reliable internet connection during the conduction of exams.[14]

Another drawback that comes with e-exams is a technical problem with the examination system in the middle of the examination process. Measures are taken to have stable and reliable platforms but cases like sudden server or software failure, or no internet connection can hamper the students' performance during the exam. Technical interferences not only contribute to frustration and stress among students and instructors but also create concerns about the reliability and fairness of tests. All in all, it can be noted that even though E-learning expansion has much of potential especially when it comes to administer online exams, it gives rise to several problems such as identity check, dishonesty, ai misuse and technical failures, which must be effectively dealt with in order to avoid unfair assessments.

2.4 Literature Review of The Types of Microcontrollers

2.4.1 Introduction to Microcontrollers

The major purpose of a microcontroller is to regulate machine activities using a fixed program that is kept in ROM and does not change over the system's lifetime. An example of a typical microcontroller is a chip that contains all the functions of a whole computer. The core elements of this microcontroller design, such as the registers, program counter, stack pointer and arithmetic logic unit (ALU), are comparable to those found in a microprocessor CPU. It also incorporates other characteristics that are necessary for full computing, such as counters, a clock circuit, parallel and serial input/output (I/O) interfaces, random access memory (RAM) and read-only memory (ROM).

Microcontrollers are designed with the goal of making a single design flexible enough for a wide range of applications to maximize market potential. While microprocessors achieve this flexibility through a broad spectrum of multi-byte instructions, microcontrollers employ a more restricted set of single- and double-byte instructions. In summary, microcontrollers, like microprocessors, are versatile devices that process information and control their environments, but they are uniquely designed to operate with a fixed program stored in ROM, making them ideal for a wide range of applications despite having a simpler instruction set.

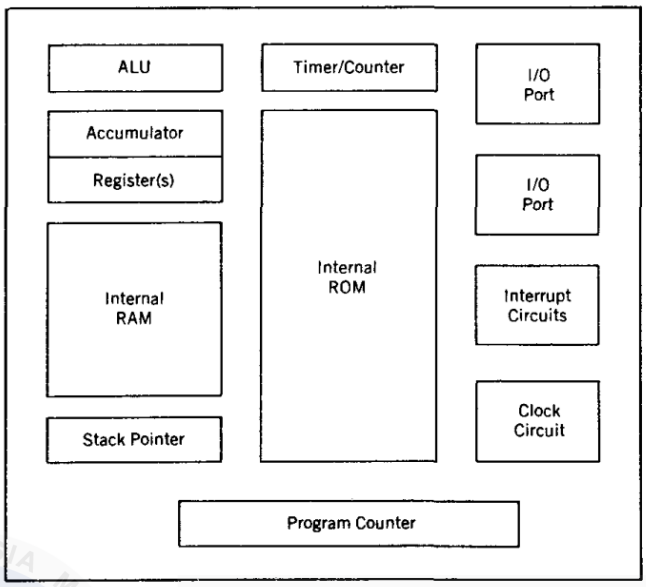


Figure 2.5 Block Diagram of Microcontroller [15]

Table 2.1 Comparison Between Microcontroller and Microprocessor

Feature	Microcontroller	Microprocessor
Main Components	CPU, memory (RAM, ROM, Flash), and peripherals (I/O ports, timers, etc.) are on-chip.	CPU, limited or no on-chip memory, and peripherals are external.
Primary Use	Specific control-oriented tasks	General-purpose computing tasks
Power Consumption	Generally lower to suit battery-operated and energy-efficient applications.	Generally higher due to more powerful processing capabilities.
Cost	Lower due to integration of components and simpler architecture.	Higher due to more complex architecture and higher performance capabilities.
Memory Architecture	Has built-in RAM and ROM, with limited expandability.	Typically uses external RAM and ROM, which can be expanded as needed.
Flexibility	Less flexible	More flexible

2.4.2 8051 Microcontrollers

One of the most popular microcontroller families in the world is the Intel 8051 family, an 8-bit microcontroller family that was created in 1981. Known by "system on a chip," this microcontroller contains 2 Timers, 1 Serial port, 4 ports, 128 bytes of RAM and 4Kbytes of ROM within a single chip. Operating as an 8-bit processor, the CPU handles data in 8-bit segments, necessitating the splitting of larger data for processing. While typically featuring 4Kbytes of ROM, some variants extend up to 64 K bytes.

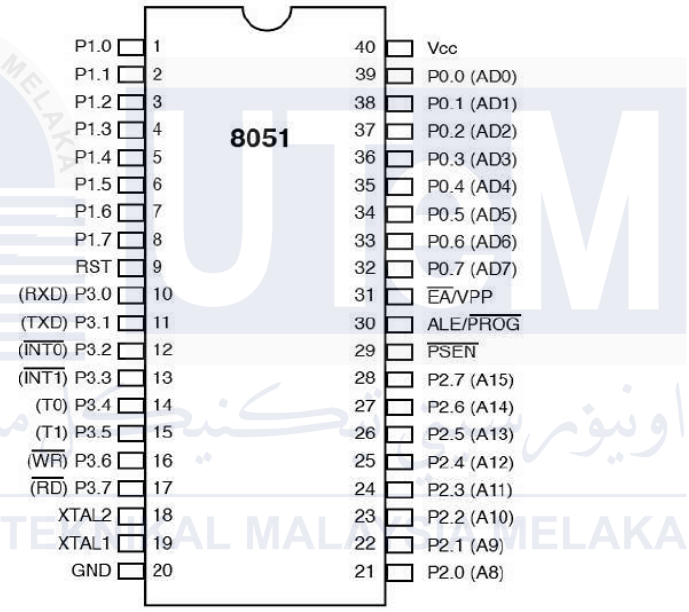


Figure 2.6 8051 Microcontrollers

2.4.3 AVR Microcontrollers

Alf-Egil Bogen and Vegard Wollan are credited with designing the AVR microcontroller, which Atmel Corporation first released in 1996 [16]. Because of their names, the acronym "AVR" stands for "Alf-Egil Bogen Vegard Wollan RISC microcontroller," also referred to as Advanced Virtual RISC. The AT90S1200, which was

introduced in 1997, was the first microcontroller to be made commercially available, but the AT90S8515 initially served as an example of the AVR design. AVR Microcontrollers come in three distinct categories, which are TinyAVR, MegaAVR and XmegaAVR. The Arduino Mega 2560 uses an AVR microcontroller from the MegaAVR category.

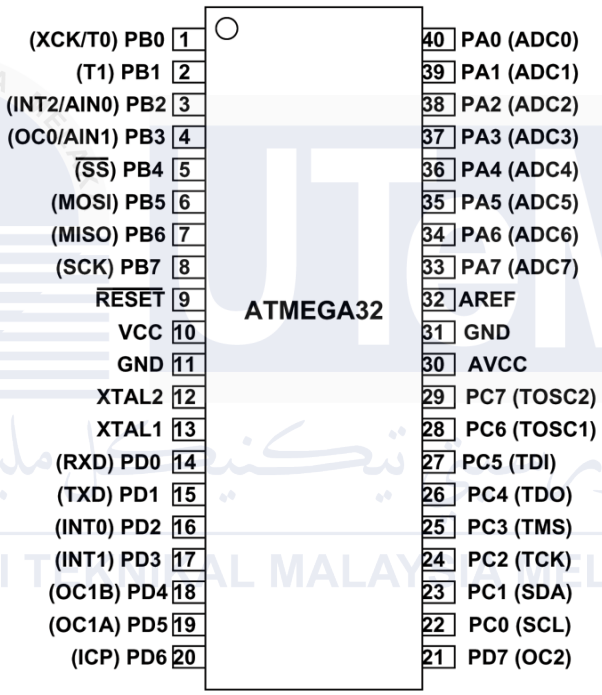


Figure 2.7 AVR Microcontrollers

2.4.4 PIC Microcontrollers

PIC, which is developed by Microchip has been found to be a fast and easy to implement microcontroller within the industry especially if benchmarked to some other microcontrollers such as the 8051. Many people have adopted it due to the advantages that are associated with it, which include the simple programming language and the simple way

of interfacing it with other peripherals. Like any microcontroller, it contains numerous blocks and peripherals including RAM, ROM, CPU cores, timers and counters, as well as the additional, yet optional blocks which are ADC and DAC. Also, it comprehends serial interface types such as UART, CAN, and SPI, and thereby provides a smooth interfacing with the outside world. The PIC microcontroller especially operates on the modified Harvard architecture and operates on the basic principles of RISC hence are faster in their operation as compared to the Von Neumann based controllers like the 8051.

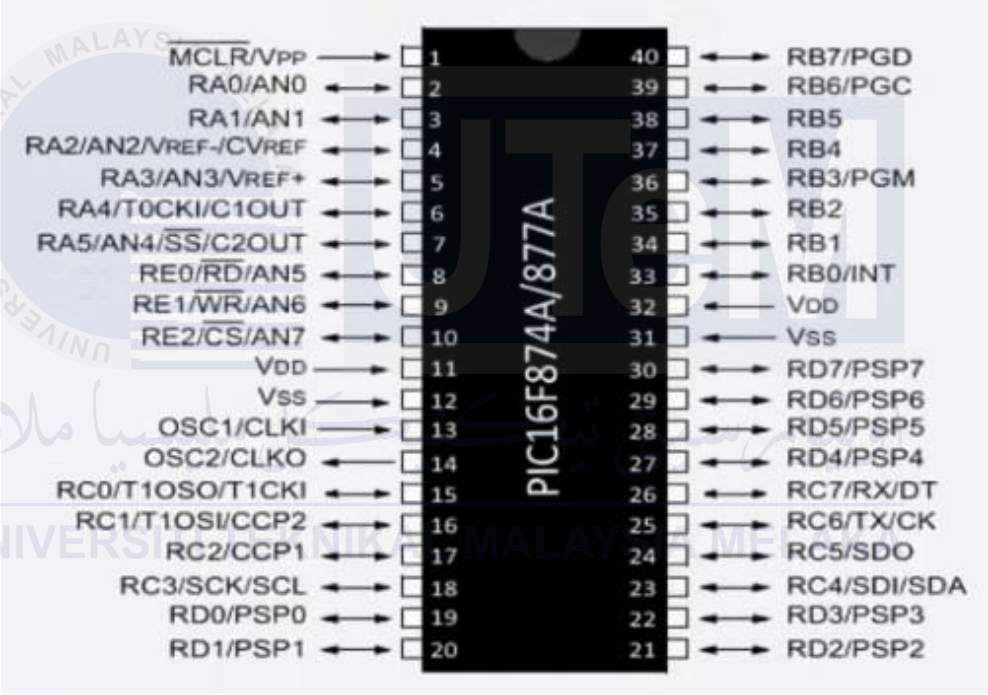


Figure 2.8 PIC Microcontrollers

Table 2.2 Comparison Between 8051, AVR and PIC Microcontroller

Feature	8051 Microcontroller	AVR Microcontroller	PIC Microcontroller
Architecture	8-bit CISC	8-bit RISC	8-bit, 16-bit, 32-bit RISC
Clock Speed	Up to 12 MHz	Up to 20 MHz	Up to 64 MHz
Memory	64 KB Program Memory	Up to 256 KB Program Memory	Up to 512 KB Program Memory

Power Consumption	Moderate	Low	Very low
Development Tools	Limited	Extensive (AVR Studio, GCC)	Extensive (MPLAB, XC8, C18)

2.5 Literature Review of The Types of Arduinos

Arduino device known to have open-source circuit board for the computers, specifically for being easy to program and to use in project creation. Arduino was established in 2005 with an aim of making it easier and cheaper to create an electronics device by anyone. Arduino is possibly the most well-known simple microcontroller board and is mostly used as a computing platform to assemble and program electronic devices. It act as an electronic gadget and programming tool that possesses functions similar to a mini size computer. This involves the ability to actively take and transmit data over the internet using various Arduino shields.

The Arduino system embodies a development platform in the shape of a hardware board as well as GUI development software. Arduino's microcontrollers are designed to be powered by 32-bit Atmel ARM processors or the 8-bit Atmel CPU and can be coded with C/C++ through the Arduino IDE. Thus, Arduino boards have become very popular among electronics hobbyists. Another feature of Arduino IDE is defining a simplified environment for writing and uploading the code connected to the standard personal computers by means of USB connection and the support of uploading new code[17]. Finally, in conjunction with the Arduino platform, users can construct engaging electronic projects that are relatively simple to create and program.

2.5.1 Arduino Uno R3

One such microcontroller board that has now become synonymous with Arduino is the Arduino Uno R3 microcontroller board. As an improved version of the old Uno, the Uno R3 has better compatibility even with the first generation of the board. There is a big improvement such as the presence of ATmega16U2 microcontroller which helps manage USB connection with computers. The Uno R3 also comes with the ATmega328P microcontroller at a clock speed of 16MHz with 14 digital I/O pins, 6 analog pins and 6 PWM pins. These features make the Uno R3 one of the most versatile boards for a variety of projects. Its low cost, simplicity, and broad functionality have made it to become one of the most widely used microcontroller boards in electronics.

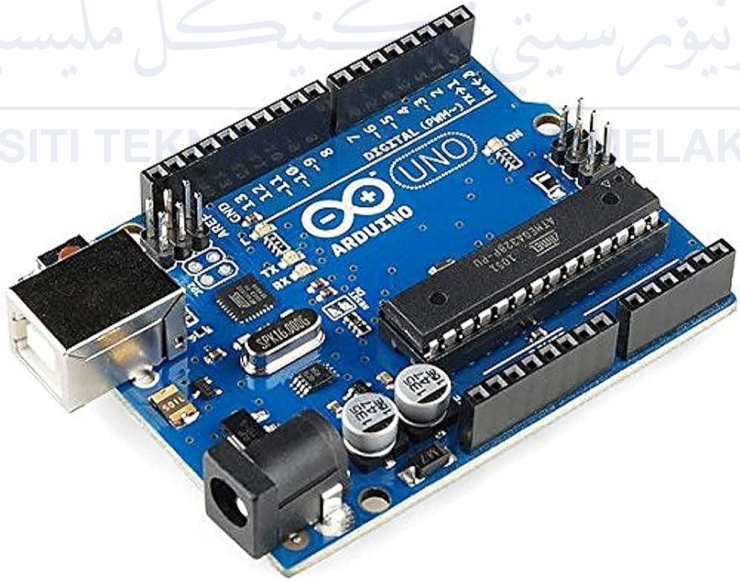


Figure 2.9 Arduino Uno R3

2.5.2 Arduino Mega 2560

The Arduino Mega 2560 is equipped with more features than the existing models. This board has the atmega2560 microcontroller and it has many digital and analog I/O pins whereby one can use it for immensely connected projects. The Mega 2560 is equipped with 16 Analog inputs, 54 Digital I/O pins out of which 15 can be used as PWM output, which helps in making the board suitable for complex and large projects like Robotics, Automation and Data Acquisition. It also has a large memory space, where the SRAM is 8KB while the flash memory is 256kB which can used to store larger applications and data set. Furthermore, the Mega 2560 has an SPI CTC16, two wire interface, two universal synchronous/asynchronous receiver/transmitters, and built in USB with full speed capabilities.

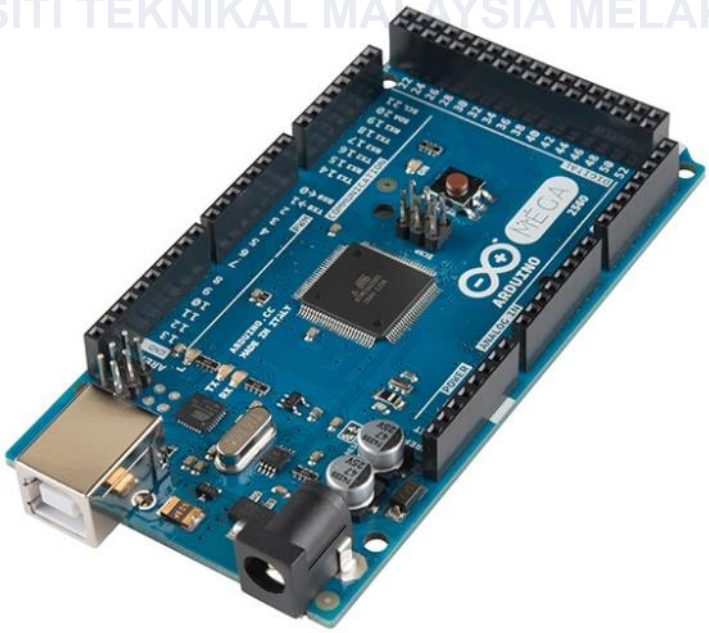


Figure 2.10 Arduino Mega 2560

Table 2.3 Comparison Between Arduino Uno R3 and Arduino Mega 2560

Feature	Arduino Uno R3	Arduino Mega 2560
Microcontroller	ATmega328P	ATmega2560
Flash Memory	32 KB	256 KB
SRAM	2 KB	8 KB
Digital I/O Pins	14	54
Analog Inputs	6	16
PWM Outputs	6	15
Clock Speed	16 MHz	16 MHz

2.6 Literature Review on Programming Languages

2.6.1 History of Programming

Between 1936 and 1945, German physicist Konrad Zuse used electromechanical relays to build a number of complex computers. However, by early 1945, most of his models had been destroyed by Allied bombing, leaving only his latest creation, the Z4. Zuse relocated to a remote Bavarian village, Hinterstein, while his research group disbanded. Working alone, Zuse resumed his project from 1943, when he had started it as a proposal for his doctoral dissertation: creating a language for expressing computations for the Z4. This language, named Plankalkül, or program calculus, was extensively detailed in a manuscript dated 1945 but remained unpublished until 1972.

Plankalkül had some of the most cutting-edge data structure features and was impressively comprehensive. The single bit was the most basic data type in Plankalkül. Integer and floating-point numeric types were derived from this bit type. Apart from the

standard scalar types, Plankalkül incorporated arrays and records, akin to structs in modern C-based languages, with the ability to include nested records.

One of the most interesting software features of Zuse was the inclusion of mathematical equations showing the present relationships between program variables. These statements are very similar to those in Java and axiomatic semantics. Zuse's manuscript contained notably complex programs, including sorting algorithms, graph connectivity tests, arithmetic operations and chess algorithms, demonstrating his remarkable breadth of programming capabilities.[18] Ultimately, Zuse's pioneering efforts laid an early foundation for the development of sophisticated programming languages, highlighting the profound influence of his innovations on the field of computer science.

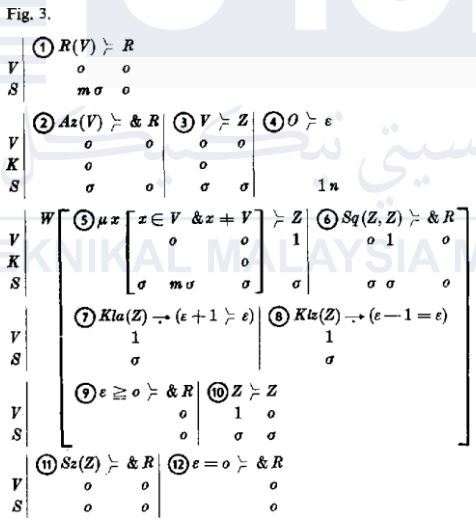


Figure 2.11 The “Plankalkül” of Konrad Zuse

2.6.2 C Programming Language

Being a high-level, general-purpose computer programming language, C was developed at Bell Laboratories by Dennis Ritchie, between 1969 and 1973. It was designed

as a body for developing a systematic, organized and adaptable language for system programming though it was majorly developed for use in the Unix operating system. C is a language with a simple grammar, which makes it easy to learn and implement. The size of a C program is small and direct memory access through pointers is possible, thus the full control of hardware is also possible. Its modularity makes use of functions as a way of dividing scripts so that they can be self-contained and can also be reused. This language is often employed in real-time applications, operating systems, system software, embedded systems and application, due to its numerous features such as high-performance, portability, and cost-effective in resource utilization.

2.6.3 C++ Programming Language

C++ was designed by Bjarne Stroustrup who embarked on its development at Bell Laboratory in 1979 then released in 1985 as an extension of C. It is designed to combine the strengths of C, freedom and efficiency, with features borrowed from object-oriented programming (OOP). C++ extends the functionalities of C by adding classes or objects that can offer facets such as encapsulation, inheritance and polymorphism. These OOP features facilitate code reuse, extensibility and maintainability hence makes C++ ideal for use in any software development particularly of large, complex systems. The Standard Template Library (STL) is a part of the language and brings set of template classes/ methods for generally used data structures and algorithms so that generic programming is not a tough task at all. One of them is C's backward compatibility feature that let users write C code in C++ programs. Also for instance, in Arduino IDE platform developers embrace use C++ making it a versatile language which is used in many domains.

Table 2.4 Comparison Between C and C++

Feature	C	C++
Main Use	System programming, embedded systems	Application software, game development, high-performance applications
Programming Paradigm	Procedural	Multi-paradigm: Procedural, Object-Oriented
OOP	There is no support for OOP concepts like polymorphism, encapsulation, and inheritance.	Supported OP features include inheritance, encapsulation and polymorphism.
Classes and Objects	Not supported	Supported
Exception Handling	Not supported	Supported via try, catch, throw

2.7 The Evolution and Impact of Android Studio on Modern Android App Development

Google has introduced a new IDE for the android application development known as the Android Studio which has replaced the Eclipse ADT. It has seamlessly developed a workflow that links each function, and the tasks involved to other functions and the tasks that they perform. For instance, there are several options available on the Android Studio in reference to and aiding in developing an application. It has a stable and efficient code editor in support with such languages as Kotlin, Java, as well as C++. The benefits include live code analysis, improved code completion, and simple refactorization. Furthermore, Android Studio comes with built integrated Gradle based build tool that assists in the management of the dependencies and build configurations of a project in a more flexible and easily expandable and configurable fashion, particularly for the multi module projects.

It is eruditely noted that with the help of an Android Studio which acts as an integrated and comprehensive IDE, the total Android development has witnessed a significant boost, and complex applications can now be developed with ease and precision. Although it is mostly applicable to the marketing sector, the case extends to the education segment and the industrial segment, which establishes it as crucial in the contemporary mobile application business. Android Studio will play a critical role as a start point and significant in the enhancement of the quality of the mobile applications.

2.7.1 The Role of Java in Android Studio

Java, however, has been in the software development industry for a long period and is therefore steady, which is a very mature language. It must be stable so that the developers can construct upon a stable platform, at the same time gain access to a host of libraries and tools. It is just a generalization that implies less bugs and more control in terms of application behavior – something which is essential when it comes to developing fine Android applications.

Java exists useful libraries and frameworks that are available for a programmer to use and integrate in Android Studio. Some of these are Glide, Retrofit and Android SDK which supports common typical application activities for instance, database access, connectivity and image loading. Thus, these libraries support developers in avoiding constant search for new features, enabling them to focus on the design of new features while making the application development as well as its performance faster and more efficient.

To sum up, Java indeed is the best option for the Android app development within the Android Studio due to the solid stability, the vast number of libraries, object-oriented approach, decent performance, and engagement of the public. The history of its presence in the industry means that it is regularly updated and is a good tool for developers who want to build high-quality Android apps.

2.8 Review of Previous Related Projects

In this section, four previous related projects that are related to the effort in transforming the conventional exams method have been reviewed. By examining these projects, we aim to identify all potential drawbacks and find the room for improvement that can be focused on in the development of Smart Answering Device.

2.8.1 Designing an Electronic Quiz Board for Exploring Mathematical Transformations

This project uses the educational kit on the hardware side, and to assess the students' understanding of the term "Transformation," a quiz with an added feature of the automatic system administration of the questions is used. Students select proper shapes to fit such

instances to match some co-ordinates on the selected graph. The kit then provides feedback to the students and therefore reduces as much as possible the teacher's interaction with the papers. Some components are TFT-LCD screen, 4x4 keypad, simulation of female pin headers, simulation of a straight pin headers in Cartesian coordinate system, buzzer, and LEDs all in one PCB. Students utilize female pin headers to position shapes on the Cartesian grid and feedback is provided through both visual and auditory cues. Green LED light means the answer was correct, while the continuous beep sound coupled with a Red LED light meaning that the answer was wrong[6]. One of the limitations is that the manual manipulation of components like female pin headers and Cartesian coordinates might be less intuitive for students accustomed to digital interfaces.

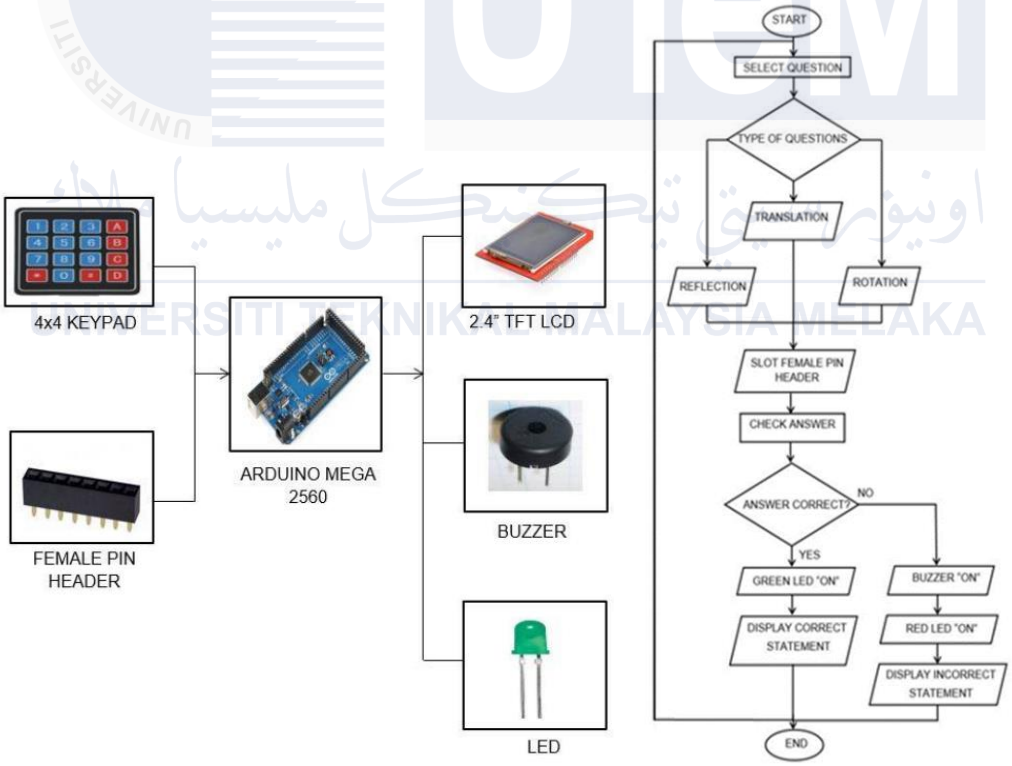


Figure 2.12 Block Diagram and General Flowchart of Educational Kit[6]

2.8.2 The Designing of An Electronic Quiz Board

This electronic board which is being recommended here is to assist in assessing the knowledge level of engineering students regarding resistors in electrical circuits. This e-quiz board differs from the traditional system of question and answer where the students are assists in the organization of questions as well as the recognition of the correct answers to such questions thereby eradicating the need for a supervisor-teacher. Some typical assignments are to achieve some output resistance in terms of some number of resistors that are on the board. The kit has also informed the students and tells them whether the connections they have formed are correct. Arduino Uno microcontroller is employed to control and manage operational functions of the Resducational Kit. It's input from a resistor and keypad, and its outputs are LED Lights, a buzzer and an LCD. 4 x 4 keypad is available on the electronic version whereby users can input choices concerning the process flow of the tests and the level of difficulty of the questions. The buzzer is used for the positive reinforcement feedback, and this is through the lighting up of different lights and its beeping for correct answers, negative reinforcement by beeping and the lighting up of the lights for a wrong answer or whenever an input is taken. Three LEDs provide visual feedback: A green light as an LED source is utilized as in indication that the answers were correct, and a red light is an LED source that acts as an indication of wrong answers, and finally, a yellow light LED is implemented in the kits and works as a sign that the kit is waiting for the response from the user [7]. The drawback of this project is it can only be conducted for one specific subject, whereby it cannot be easily adapted for use in other educational contexts.

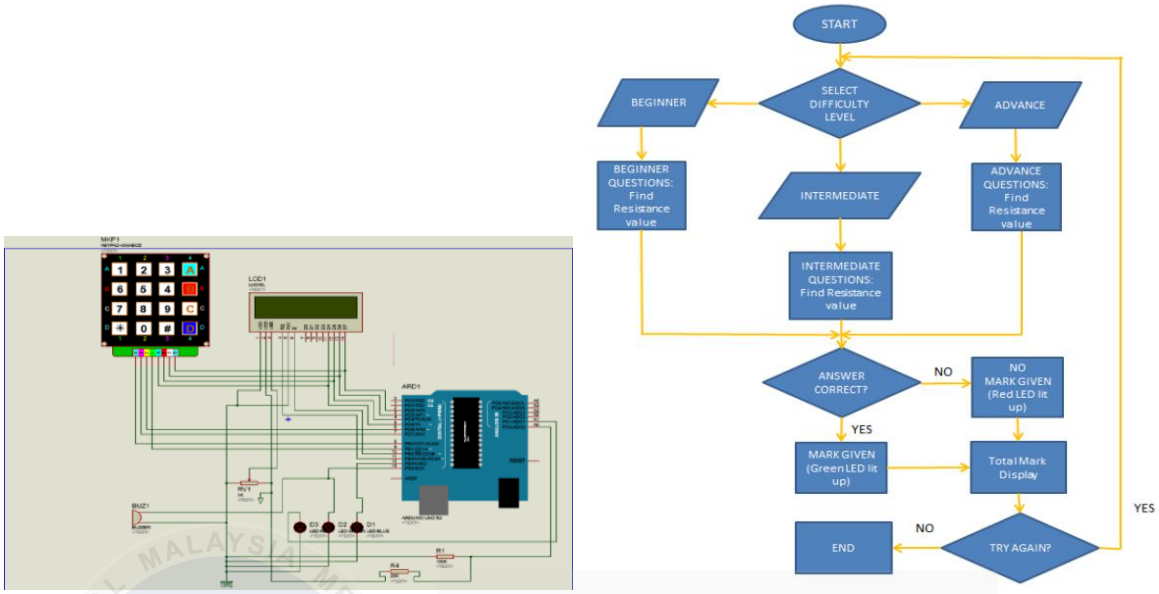


Figure 2.13 Schematic Diagram and Flowchart of Resducational Kit[7]

2.8.3 Designing of An Electronic Quiz Board That Assesses Students' Comprehension of The C Programming.

Based on the above findings, the e-FLOWCHART is an effective instructional tool that is used to improve the primary school students understanding of C programming and the concept of flowcharts. There are three major stages in the implementation of the project, which include the input phase, the control phase and the output phase. The input stage uses variable resistor for each command such as RES and R2 and a keypad as an interface. Control stage controls the received data and the data that will be given out to the other circuits, which is made use of Arduino Mega 2560. The output stage consists of those components that provide feedback to the user include buzzer, LEDs, a TFT LCD and a 20 x 4 LCD screen.[19]. The reliance on manual input through keypads and variable resistors can be

cumbersome and less user-friendly. Additionally, the need for users to manually place commands on the flowchart can lead to errors and reduce efficiency.

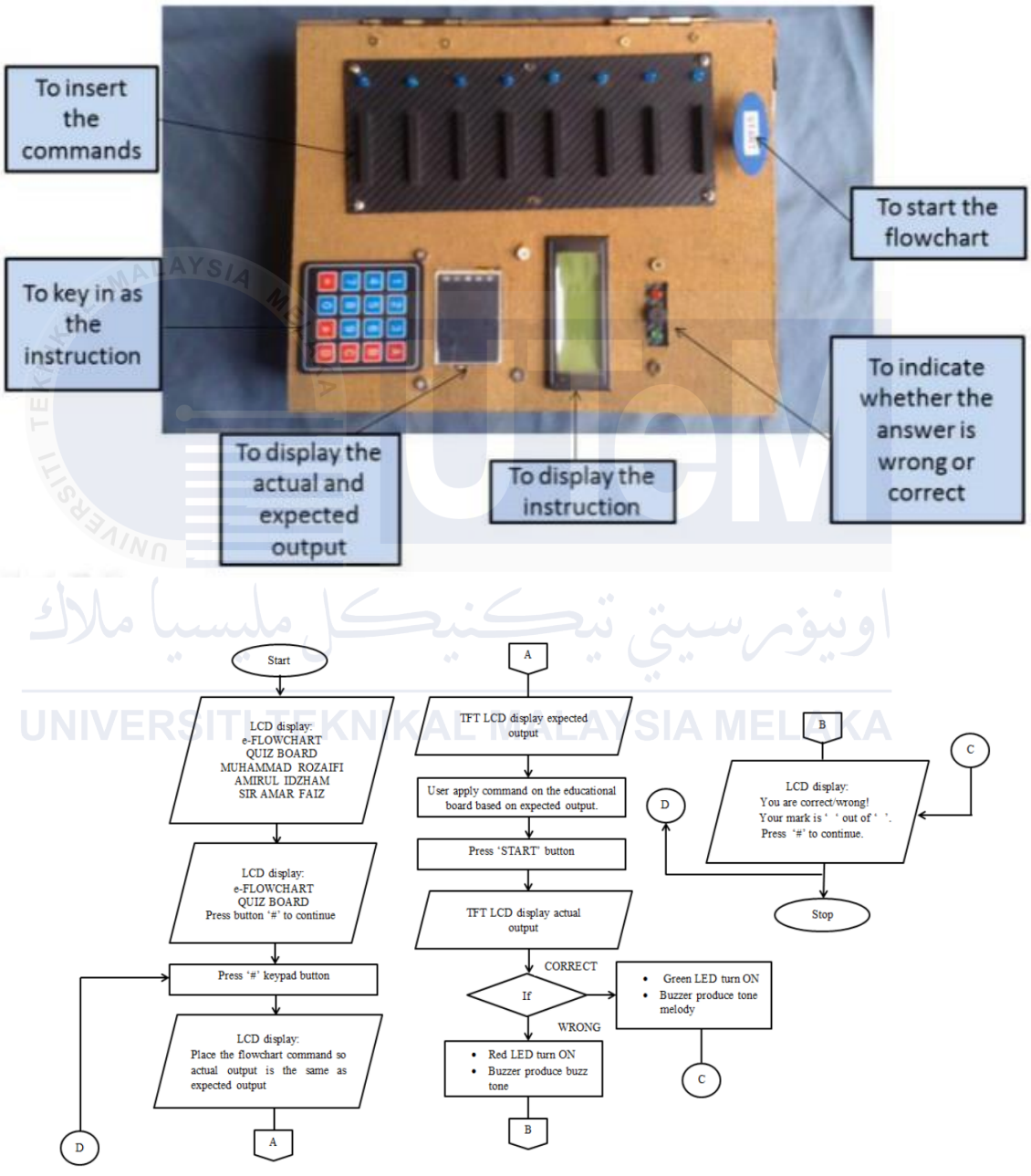


Figure 2.14 Project Prototype and Flowchart of e-FLOWCHART[19]

2.8.4 Designing of A Quiz Kit and Electronic Educational Simulator for Logic Gate Combinational Circuits by Utilizing Arduino.

With an emphasis on combinational logic circuit creation, the e-Logic Training Kit (e-LTK) is intended to serve as an educational tool to supplement course material and evaluate student understanding in Digital Electronics disciplines. Students use the kit to assemble logic gate combinations on a surface board trainer kit. After finishing, the input is processed by the microcontroller, which then outputs a high (1) or low (0) timing diagram. A microcontroller, inputs, and outputs make up the e-LTK project. The timing diagrams are shown on a 2.4-inch TFT LCD. Users can select choices including simulation and assessment modes using a 4x4 keypad. Users can inspect the outputs and simulate circuit connections in learning mode. In the Assessment mode, users must match input and output timing diagrams to answer nine increasingly challenging questions.[20] However, the e-LTK relies heavily on manual connections and a keypad interface, which can be time-consuming and prone to errors. Additionally, the assessment mode involves manually matching timing diagrams, which may not provide immediate and comprehensive feedback.

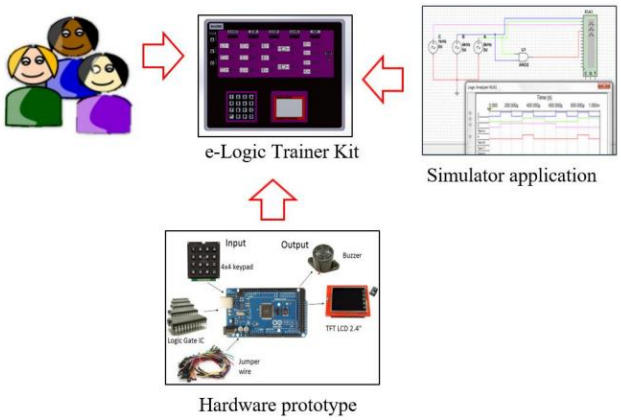


Figure 2.15 Block Diagram of e-LTK[20]

Table 2.5 Comparison Between Previous Related Projects and Propose Project

Project Title	Designing an Electronic Quiz Board for Exploring Mathematical Transformations[6]	The Designing of An Electronic Quiz Board[7]	Designing of An Electronic Quiz Board That Assesses Students' Comprehension of The C Programming .[19]	Designing of A Quiz Kit and Electronic Educational Simulator for Logic Gate Combinational Circuits by Utilizing Arduino.[20]	Development of Smart Answering Device for Exam and Quizzes by Using Arduino Mega 2560
Functionality	Assesses students' understanding of Transformation by conducting a quiz that automate the question delivery process.	Assesses engineering students' understanding of resistors in electrical circuits.	Assesses primary school student' comprehension of C programming and flowchart ideas.	Evaluate student understanding in Digital Electronics disciplines	Assesses student on objective and subjective question, incorporating a grading system and utilizing android application for collecting and displaying data
Hardware	Arduino Mega 2560	Arduino Uno	Arduino Mega 2560	Arduino Mega 2560	Arduino Mega 2560, HC-05 Bluetooth module
Software	N/A	N/A	N/A	N/A	Android application
Component used	TFT LCD, 4x4 keypad, female pin headers, straight pin headers, buzzer, LED	Resistor, 4x4 keypad, LED, buzzer, 16x2 LCD	Resistor, keypad, buzzer, LED, TFT LCD, 20x4 LCD,	TFT LCD, 4x4 keypad, logic gate ic, buzzer	Push button, ps/2 keyboard, graphical LCD 128x64,

					buzzer, LED
Drawback	The manual manipulation of components like female pin headers and Cartesian coordinates might be less intuitive for students accustomed to digital interfaces.	Cannot be easily adapted for use in other educational contexts.	The need for users to manually place commands on the flowchart can lead to errors and reduce efficiency.	Relies heavily on manual connections and a keypad interface, which can be time-consuming and prone to errors.	

2.9 Summary

The literature review is based on various educational devices and if means applied to higher the ways of students' learning and understanding of various courses through innovative quizzing system. The first project, an e-quiz board for the exploration of mathematical transformations, limits the teacher's interactive involvement as it serves as the answer delivery system/questions board as well as a multiple-choice instant feedback generator. It makes sense for that scope because it can be programmed to solve certain problems like mathematical problems provided inputs are keyed in manually. The second project involves a quiz board about the resistors that are used in the electrical circuits and in this case, the Arduino Uno is used in the management of the quiz answering process and the

results which are displayed using the lights and a buzz sound from the two different LEDs and a buzzer respectively. As a learning model for resistor concepts, it is efficient. However, it is not very useful or applicable to other topic areas outside the teaching resistor concepts. The third project is the e-FLOWCHART which is used to enhance the learning of flowchart concepts and C-programming among primary school students. However, there are some issues mainly in having the manual entries and other occasions of errors too. The fourth one is the e-Logic Training Kit which features the instruction of combinational logic circuits with the help of microcontroller that includes the option for displaying timing diagrams on the TFT LCD. However, the connections and assessments are not as neat and may be erroneous at that. Additionally, the overall process will be comparatively longer in this case, which can also lead to wrong results. The review likewise reinforces how it is important to address these factors and methodize more effective educational aids.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this section, various procedures and activities included in the general planning of the Smart Answering Device will be presented. First, the selection and assessment of the tools to be chosen for their further adoption to the overall concept of the sustainable development of the concept will be outlined in advance, adhering to the principles of the effective use of environmentally friendly tools and technologies. It will involve a discussion of a project planning flow chart that entails all the developmental plan of the project. A project system flowchart will also be created to showcase the system flow of the device and all the conditions that should be considered. In addition, a block diagram which presents project layout with an aim at identifying the place of the project and how the blocks would look like within the framework of the project will also be created. As the final part of the paper, the description of the specific hardware and software to be used and the focus shall be made to their function and relevance in the achievement of the goals of the project.

3.2 Selecting and Evaluating Tools for a Sustainable Development

Some critical issues are considered in the pursuit of a sustainable development approach in this project. To begin with, energy-efficient components that will require the

least energy will be chosen. This means using sensors, LED lights, and power consumption circuits with little power to reduce impact to the environment. Another consideration is the disposal aspect, at the end of the life span of a particular part/ component, it is preferable if the material should be eco-friendly and should have minimal recyclability while including substances that are toxic to eco-system.

In addition, it is important that utilization of resources, especially electronics, that should not be a guise for wastage. Evaluating the effectiveness of the long-lasting constituents like, Arduino Mega 2560, a graphical LCD, push buttons, and peripheral devices ensures long-term reliability and, therefore, fewer replacements to a less expensive but less reliable component. It also serves the fact of resource conservation and is helpful in lowering the burden of treatments of electronic wastes.

Consequently, the accessibility and easiness to use of the components should also be considered. They include the way each component is handled and installed together with the operational and maintaining factors of the entire structure that define the sustainability of the project development. An emphasis on tools supplied from manufacturers and training materials ensures that after the training session is complete, the operator can safely and in the long term perform operations on the device. In this aspect, the Smart Answering Device has been planned with clear goals for sustainable development. Tools that aid selection and evaluation will be applied based on the energy efficiency, material sustainability, resource use and users' accessibility as to maximize the inputs required for the development of the Smart Answering Device in as sustainably as possible.

Figure 3.1 Sustainable Development Goals

3.3 Flowchart

3.3.1 Project Planning Flowchart

First, Project Planning involves outlining the project's vision, scope, and objectives. Next, Research and Data Collection gathers relevant information to inform project decisions. The Feasibility Study assesses the practicality of the project. Title Proposal submits the project title for approval, and if not approved, revisits planning. Identify Project Objectives and Scope clearly defines goals and scope. Literature Review conducts a comprehensive review of existing related literature. Methodology develops a detailed execution plan.

Component Selection chooses necessary components, including Hardware Simulation to ensure functionality and Software Design for project software. Work as Expected? checks functionality, with debugging if necessary. Hardware Implementation involves building the hardware. Integration and System Testing combines and tests hardware and software. Results and Discussions analyze testing outcomes and Conclusion summarizes the project findings.

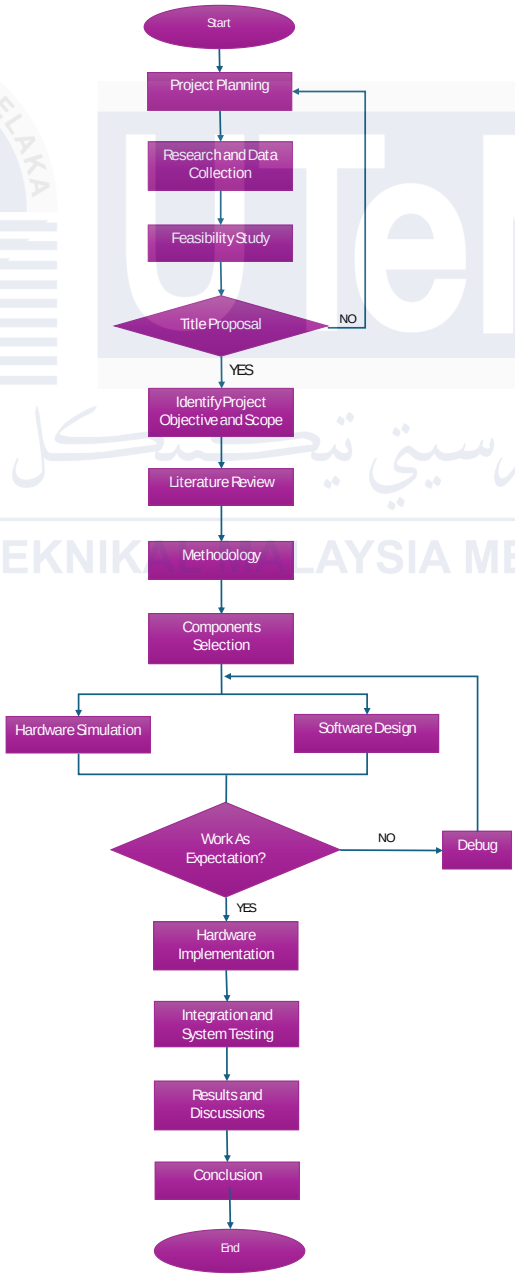


Figure 3.2 Project Planning Flowchart

3.3.2 Project Flowchart

A project flowchart is a crucial tool that offers a clear path from beginning to end by graphically representing the steps and decision points involved in a project. By breaking down complex processes into manageable steps, a project flowchart facilitates better coordination and tracking of progress. In the development of a Smart Answering Device, the project flowchart will provide guidance through key stages, from initial planning and component selection to integration, testing and final deployment, ensuring that the project is completed efficiently and meets all specified requirements.

Figure 3.2 illustrates the project flowchart of Smart Answering Device. Initially, the user needs to connect to the HC-05 Bluetooth module. After the connection is established, the user can send all the exam questions to the Arduino Mega 2560. When all the data had been received by the Arduino, the graphical LCD displays the course name of the exam, and the ISD 1802 will be triggered to give instructions to all the candidates. Then, the system will prompt students to input their name and matrix number. At this point, the system will initialize startTime = currentTime and endTime = Total + startTime to establish the exam period. Continuously, the system will check the currentTime <= endTime to make sure the examination does not schedule overtime.

If the time remains within the specified range, the system will determine whether the question is either objective or subjective. For both scenarios, the system will begin by displaying the question number and the preset questions. For objective questions, input is obtained from the push buttons; For subjective questions, input is obtained from the ps/2

keyboard. Objective answers are stored using the push buttons whereas subjective answers are stored using the enter key of ps/2 keyboard. Before advancing to the next question, students can decide whether to submit or proceed to the next question. Nested if-else looping will be used to control all the operations. If they choose to submit their answers, the exam will be terminated.

When the endTime exceeds currentTime, the exam will be terminated, and the system will output score and mark for objective question on the LCD. Finally, all data will be transmitted to the Android app by using HC-05 Bluetooth module. The lecturer can store all the data received into the SQLite database. Lastly, lecturers can use PyCharm to run the python code to generate an excel file that stores all the student's results and create a histogram for analysis purposes. The whole process is completed.

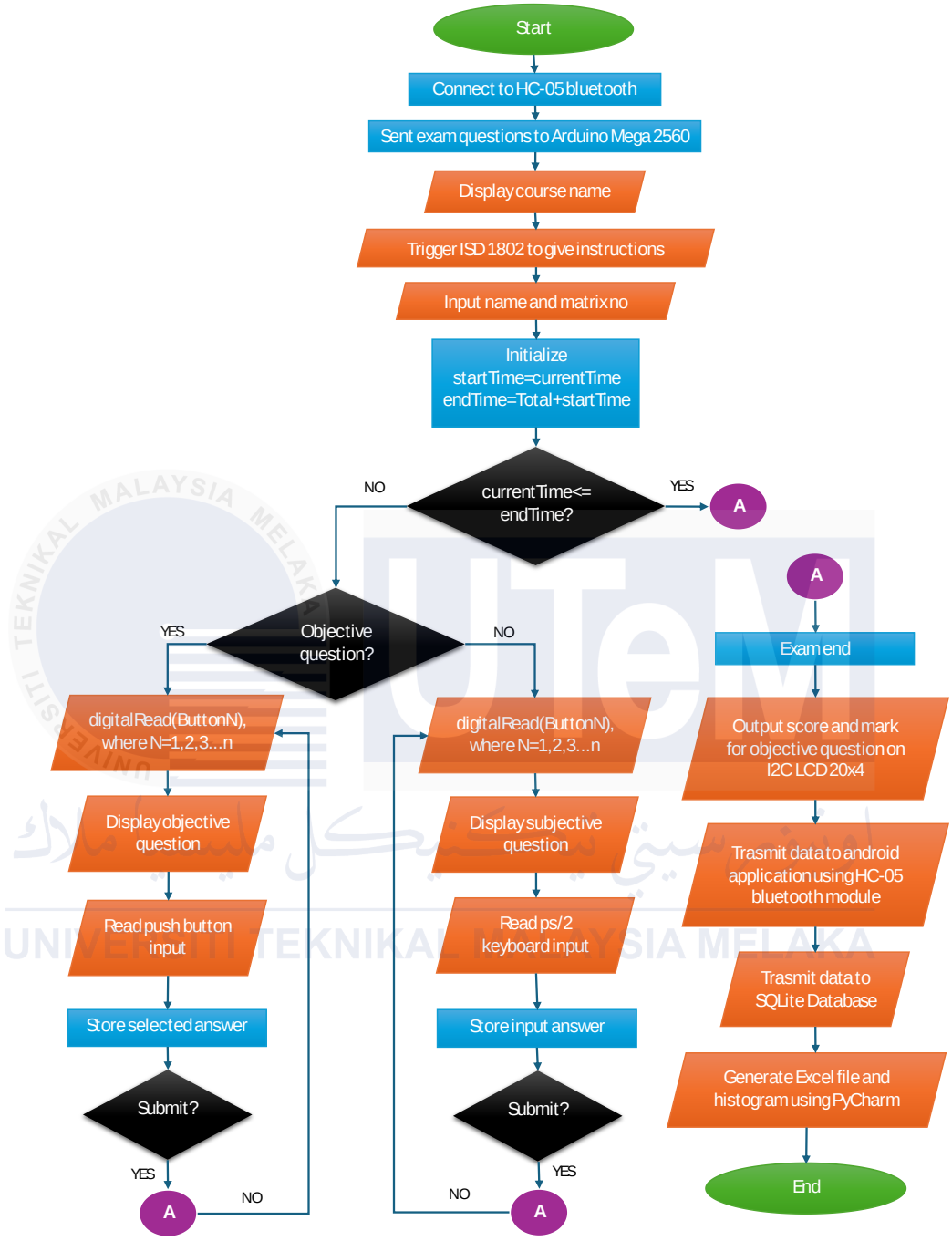


Figure 3.3 Project Flowchart

3.3.3 Project Block Diagram

A Project Block Diagram is an illustration of a project's architecture that shows the links and linkages between its modules or components. It gives a high-level overview of the project's organizational structure and emphasizes how signals, data and control move through the system. Project Block Diagrams show how various parts, including microcontrollers, sensors, actuators and communication modules, interact with one another to accomplish the project's goals by using standardized symbols to represent them.

Figure 3.3 illustrates the block diagram of Smart Answering Device. The left part of the block diagram consists of all the input components that will be used whereas the right part of the block diagram indicates all the output components. The input components for this project are push buttons and the ps/2 keyboard. The central processing device is the Arduino Mega 2560 microcontroller. Lastly, there are seven main output components which include HC-05 Bluetooth module, I2C LCD 20x4, buzzer module, LEDs, ISD 1802 voice recording module, Android application and SQLite database.

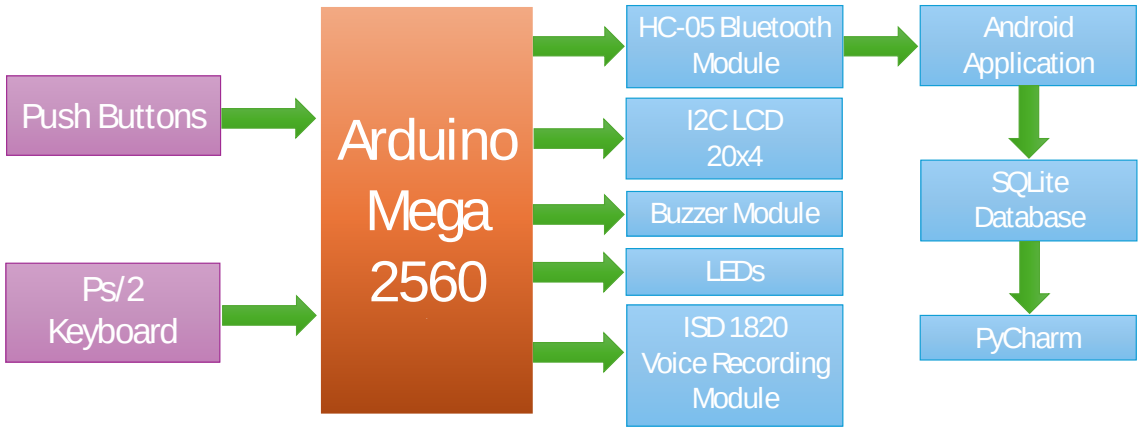


Figure 3.4 Project Block Diagram

3.4 Project Schedule

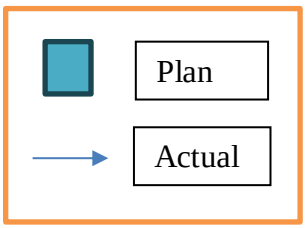
A Gantt chart has been used for project scheduling purposes, so that every think is done before its deadline, at the same time making sure every week throughout the semester will be organized smoothly and effectively. The horizontal row inside the Gantt chart illustrates the task that will be scheduled while the vertical column shows the timeline of each task. With the existence of Gantt chart, every task will be done according to plan and avoid the tasks from interfering with each other.

Table 3.1 Gantt Chart PSM1

NO	TASK	WEEK													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Title Planning and Research														
2.	Proposal Writting														
3.	Submission of Proposal (Title & Synopsis)														
4.	PSM1 Briefing & Information Literacy Programme														
5.	Thesis Briefing														
6.	Introduction Writing														
7.	Progress Work 1 (W6)														
8.	Literature Review														
9.	Methodology														
10.	Progress Work 2 (W12)														
11.	Preliminary Result Writing														
12.	Conclusion Writing														
13.	Submission of BDP1 Report														
14.	BDP1 Presentation														
15.	Project Demo														

Table 3.2 Gantt Chart PSM2

NO	TASK	WEEK													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Planning and Research														
2.	Define Requirements and Features														
3.	Android App Development														
4.	Bluetooth Management Development														
5.	Ps/2 Keyboard Integration														
6.	Android App Designing														
7.	Final Prototype Designing														
8.	Database Setup														
9.	Results and Discussion														
10.	Functional Testing														
11.	Project Analysis														
12.	Conclusion and Recommendations														
13.	Poster Designing														
14.	PSM 2 Draft Submission														
15.	Presentation and Thesis Submission														



3.5 Hardware Specification

3.5.1 Arduino Mega 2560

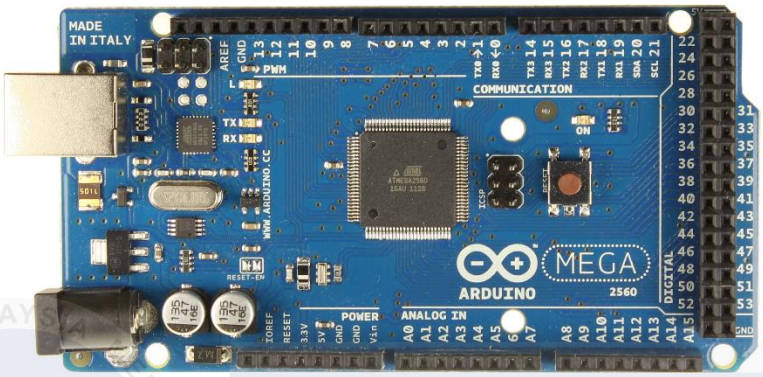


Figure 3.5 Arduino Mega 2560

The Arduino Mega 2560 has been chosen as the centralized device due to the following benefits. The board has increased I/O operations, adequate interfacing capabilities for needed sensors, actuators, and other elements that might be necessary in the project. The data of the objectives and subjective questions needs to undergo complex programs and handling and can take a significant amount of space. Arduino Mega 2560 has 256 kB flash memory and 8 kB SRAM to make the process possible. Real-time applications such as grading and user input response will be facilitated with the 16 MHz clock speed of the Arduino board. The presence of multiple interfaces of serial communication including UARTs in the board helps in having establish connections with peripheral devices like the Bluetooth devices.

The Arduino Mega board serves as the brain of the smart answering device. It handles all the user input through the push buttons and ps/2 keyboard. The board also controls a graphical LCD, displaying questions, instructions, and feedback to the students.

Timing for exams is managed by the Arduino, which activates a buzzer to alert students when time is running out or the exam is over. Data processing and storage are conducted on the board, performing real-time scoring for objective questions and storing results. Communication with an Android application is facilitated via an HC-05 Bluetooth module, transmitting student data, answers and scores for further analysis and display on the app.

Table 3.3 Specification of Arduino Mega 2560

Specification	Details
Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage Range	Recommended: 7-12V, Limits: 6-20V
Digital I/O Pins	54 (including 15 PWM outputs)
Analog Input Pins	16
UART Ports	4 (hardware serial ports)
Clock Speed	16 MHz
Flash Memory	256 KB (8 KB allocated for bootloader)
SRAM	8KB
EEPROM	4KB

3.5.2 HC-05 Bluetooth Module

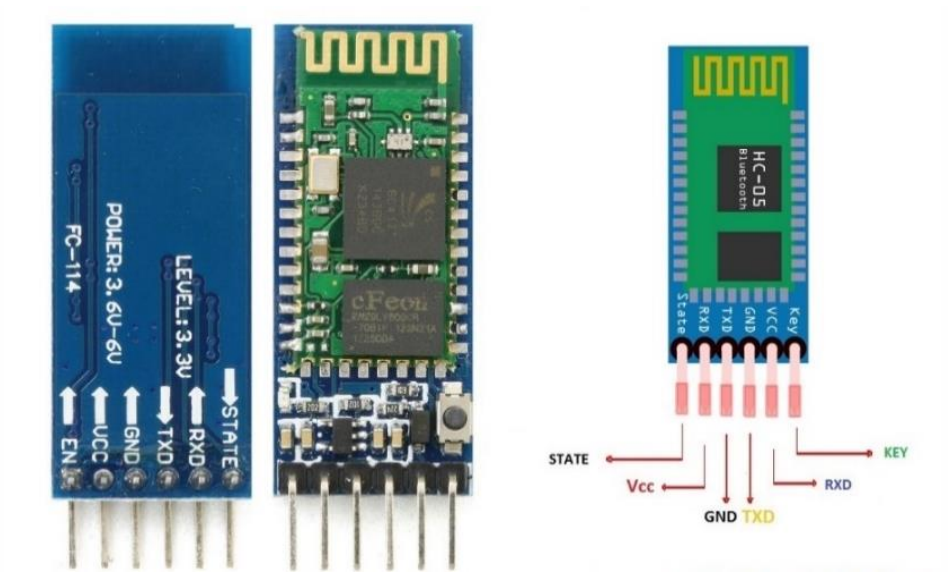


Figure 3.6 HC-05 Bluetooth Module

The HC-05 Bluetooth module provides essential wireless communication capabilities. Since it works on a voltage of between 3V and 5V, it can be used in combination with microcontrollers including the Arduino Mega 2560. Its voltage ranges from 3.6V to 6V and is equipped with Bluetooth v2. 0+EDR that ensures the dependable as well as seamless exchange of data information. This can also work as both the master and the slave modes, opens the possibility of flexibility in the network configuration. Less complicated to configure using AT commands and has a light indicating the modem status, which makes this product easy to use. This kind of design is preferred because there are numerous benefits accompanying integration, low costs, and other requirements for extending the data transmission network. In this project, the HC-05 Bluetooth module allows wireless connection between the device and android application so that the real-time transmission of exam's data is possible.

Table 3.4 Specification of HC-05 Bluetooth Module

Specification	Details
Bluetooth Standard	Bluetooth V2.0 + Enhanced Data Rate (EDR)
Operating Voltage	Ranges from 3.6V to 6V
Configuration Modes	Can function as either master or slave
Default Baud Rate	9600, adjustable
Power Consumption	Low in idle mode, higher during active transmission
Data Transmission Speed	Up to 3 Mbps

3.5.3 I2C Serial Interface 20x4 LCD Module

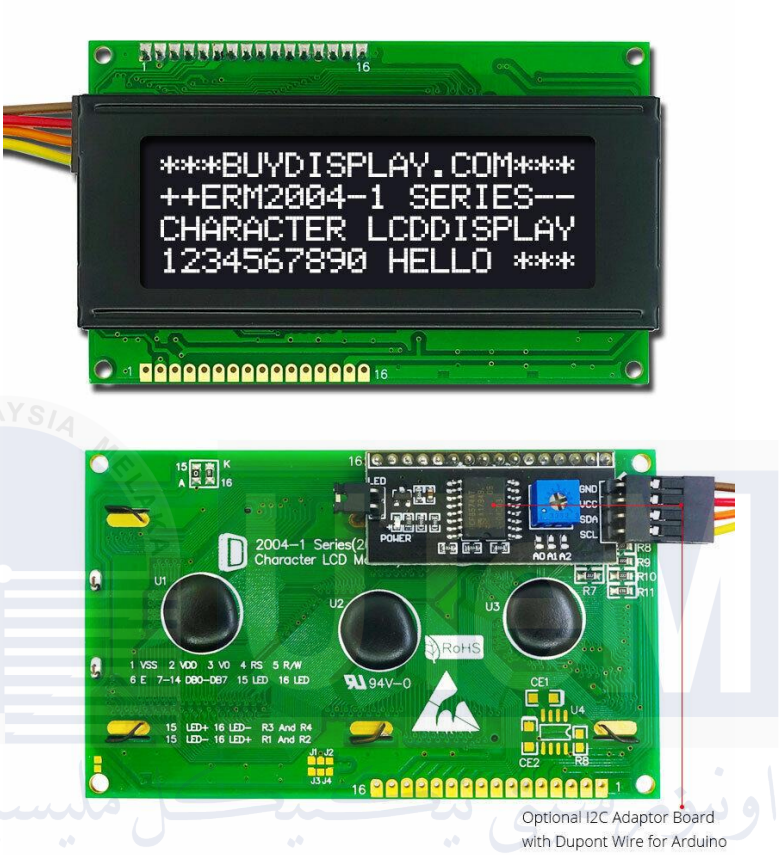


Figure 3.7 I2C Serial Interface 20x4 LCD Module

3.5inch I2C serial interface 20x4 LCD module displays are clear and readable displaying four lines of 20 characters making it perfect for user interaction. As a result, this module relates to I2C interface so it can easily be attached to the Arduino Mega 2560 with just two data pins (SCL and SDA) and reduced the wiring complexity. Clear display, capable of displaying essential text information with a good readability, to display essential examination data or other contents. At only 5V, the module can run on an Arduino Mega 2560's operating voltage, which fits some rigidity to power management and wiring. It doesn't support graphics like a graphical LCD, but since it supplies clear text, the 20x4 character display is excellent for your project.

3.5.4 Pushbutton

Figure 3.8 Push Button

Push buttons are essential components for students in answering objectives questions, whereby the students can simply push the buttons to choose their desired answers. They involve positional characteristics such as enabling the switch to only be on when the button is pressed and retracting the switch when the button is released. It is also worth noting that all the push buttons in this microcontroller are normally open (NO), this means that the push button is open by default. It has a simple wiring system and does not necessitate a lot of settings, whereby the single wiring is connected to the DIGITAL I/P pin on the Arduino Mega 2560 board.

3.5.5 Ps/2 Keyboard

Figure 3.9 Ps/2 Keyboard

PS/2 keyboard act as central input device for the subjective questions answering. It is preferred since it has one common appearance, which is large dimensions of the primary input space. In this project, the PS/2 keyboard is used in the beginning of the exam, where students enter their name and matrix number to allow the program to administer certain student identification to the testing process. Furthermore, for the questions which are-answer-informed, for example questions that needs the students to write down their answers, the students type their answers on the PS/2 keyboard since this enables them to express their ideas about several aspects of knowledge and refute them basing their arguments on their knowledge.

3.5.6 ISD1820 Voice/Audio Record and Playback Module

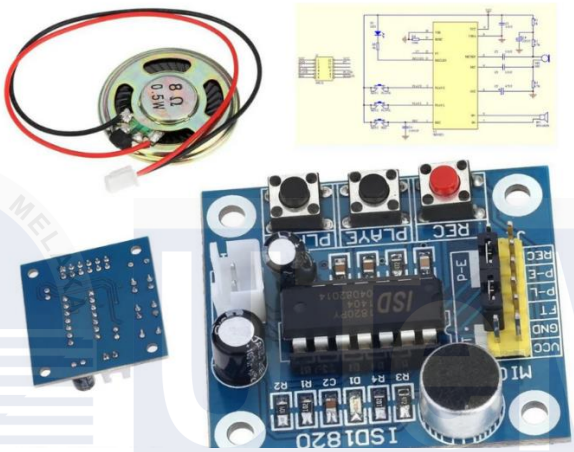


Figure 3.10 ISD1820 Voice/Audio Record and Playback Module

ISD1820 is a recording and playback module. In the same module, it has the built-in recording function and playback function which allow it to be reused repeatedly. When we re-record a new audio, the previous recording gets erased, and the new recording gets loaded or gets saved into the IC of ISD1820. This module has a built-in condenser microphone in it, so we do not need external microphone to record sound into it. This module also comes with a speaker which can be used to play the recorded audio. The first pin on the left side of the module is VCC, followed by GND, FT, P-L, P-E and REC pin. Total pin of this module is 12 in which six are used for connectivity, two are used for FT and another two are used for P-E. To record an audio, we need to press the record button and hold it until the audio message is completed. By default, the module can record up to 10 seconds, however the recording time can be changed by changing the resistor on top of the module.

The PLAYE button indicates play edge triggered, which means the entire audio is played one time when we press this button. On the other hand, the PLAYL button indicates play level triggered, which means if we press this button, the audio will be playing; As soon as we release the button, the audio will be stopped.

3.5.7 Buzzer Module

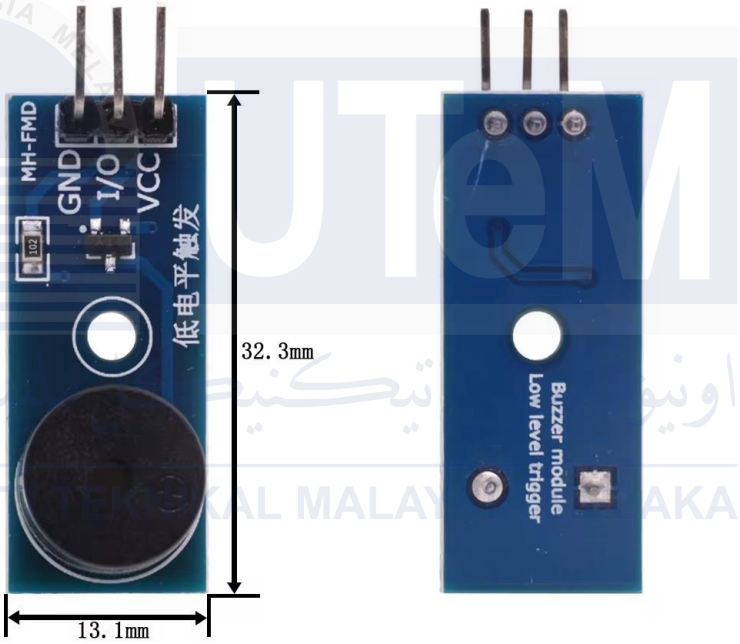


Figure 3.11 Buzzer Module

The buzzer module produces sound waves when an electric current passes through it. It consists of three pins which include GND, VCC, and I/O. A compact size and low power consumption make this module able to provide clear audio feedback. The real-time sound feedback provided by the buzzer enhances the usability of the device, keeping students informed of the remaining time and enabling them to manage their time effectively throughout the examination.

3.5.8 LED

Figure 3.12 LED

LEDs are used to provide real-time feedback to the student so that student can know their score and mark for objective question as soon as the exam is done. This means that students can quickly comprehend their performance once the exam is completed. Several attributes of such semiconductor gadgets to address this role can be of several qualities such as more energy-efficient, robust construction that lasts longer, lower size and density, as well as faster and more responsive. After a given examination has been conducted and the result calculated using the Arduino microcontroller, LED light up to indicate the success or failure of a student. Green LED light up indicates that student mark is more than 40% (pass) whereas red LED light up indicates that student mark is below 40% (fail).

3.6 Software Specification

3.6.1 Arduino IDE

Figure 3.13 Arduino IDE Logo

The main application software used for writing instructions to the Arduino microcontroller is called the Arduino Integrated Development Environment (IDE). Several features such as code editor tools, code editor geo-syntax highlighting and auto-completion making it ideal for microcontroller code development and coding refinement. In addition, it supports tons of functions and peripherals through its built-in libraries. In other words, it provides a set of software bricks for constructing the complex features required for the project.

Furthermore, the micro-controller and the PC can interact through the serial monitor in real-time which aids in the display of the acquired data and debugging during the development period. The Arduino IDE helps to build and iterate functions of a project to improve their efficiency through successive prototyping. Finally, Arduino compatibility provides an opportunity to use many available libraries and to find support in case of any problems and cooperation.

3.6.2 Android Studio

Figure 3.14 Android Studio Logo

Given its versatility to work in multiple environments and due to many of its features that focus solely on Android application development, Android Studio is the leading application development suite. It employs integrated development environment (IDE) which contains tool plans, execution, debugging and developing tests on Android applications. The code-based editor enhances coding by including such options as syntax highlighting as well as code completion while the layout-based editor is an enhancement to UI design in view of its layout editor's ability to be dragged and dropped. With this app, developers can implement easily navigation and UI for application, add Bluetooth for connecting functions in devices, and check the device and its functions for qualitatively work. Moreover, Android

apps deployment tools are integrated into Android Studio, this array of resources, documentation and help materials allow the developers to easily fix issues and optimize the app creation process.

3.6.3 SQLite

Figure 3.15 SQLite Logo

Leveraging SQLite, users can store and manage data within applications without a server. The methodology entails creation of schema, setting up of a database involving the initialization of a connection to a file, tables with specific designed schemas and they are filled with data in use of INSERT statements. With SELECT, users can query the data. Users can update data into or delete it from the database with UPDATE and DELETE commands. Error handling is hit right, checking that the application is stable when performing database

operations, and closing the connection at the end of the operations to free memory. Backup, and optimization using VACUUM command are the routine work that need to be performed to maintain the integrity and performance of database. This approach offers a convenient, self-contained solution for small to medium sized data management needs in applications.

3.6.4 Tinkercad

Figure 3.16 Tinkercad Logo

Among the all the simulation tools used to simulate the device, Tinkercad remains central as the tool that enabled the simulation process to move smoothly. Tinkercad is the most suitable for electronic circuit design and modeling due to its rich feature set that consists of components from microcontrollers, sensors, and displays with a very simple and easy to use interface. These main aspects of project work can be answered by utilizing Tinkercad, since it includes simulation and circuit designing, choosing and implementing components, testing as well as prototyping circuits, circuit visualization and analysis. With

the help of such real-life emulation which is provided by this software, engineers are also able, to experiment and optimize the electronic circuitry of the device, making sure it works at its best and fulfill all requirements set by the engineers and the project before it is launched for real.

3.6.5 Wokwi

Figure 3.17 Wokwi Logo

In addition to Tinkercad, Wokwi is an elaborate online-based tool applied for simulating and prototyping of circuits together with microcontroller projects. It provides the user with a virtual platform, devoid of the need for physical infrastructure, to implement, deploy, and iron out problems within their projects. The part offerings that Wokwi provides are extensive and this includes the microcontroller and other necessities like sensors and displays and as such, users can build exhaustive projects easily. The live interaction feature

of Circuit Spector enables developers to examine their circuit and code behaviors and even adjust them during program development, hence reducing extensive cycles. In a nutshell, Wokwi is an invaluable resource that helps with electronics and embedded systems since it makes developing with the latter much easier thanks to this interface.

3.6.6 PyCharm

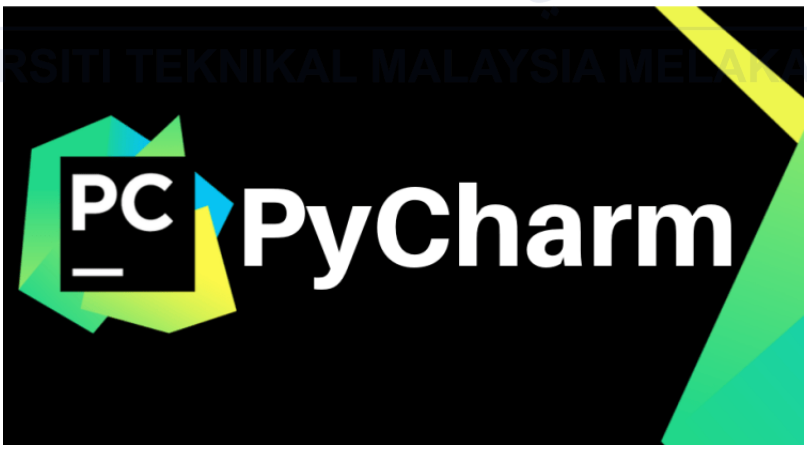


Figure 3.18 PyCharm Logo

An IDE is an integral part of the data analysis process, especially in generating Excel files and visualizations from a database; it does so for Python, and this IDE is called PyCharm. With Python libraries such as sqlite3, pandas and matplotlib, PyCharm helps users

to establish database connections (e.g., SQLite), read and manipulate data, then save to structured Excel files to continue their analysis. Furthermore, matplotlib users can use visual representations to analyze and interpret the data as shown in histograms. And streaming this workflow using PyCharm makes it the most efficient way for complete data analysis.

3.7 Summary

The development of the Smart Answering Device was based on a strong methodology and implementation of several approaches that amalgamate tools, components, and relevant software for effective and constructive project development. The choice of tools and their assessment concentrates on such criteria as energy efficiency and sustainable use of materials and recourses. Subsystem helps are selected based on their compatibility, use in the project as well as contribution towards the project objectives.

Flowcharts are used to depict the workflows, project stages, and system designs to facilitate communication and coordination of a project and monitor its progress. As for the project hardware specifications, they indicate what are the components and what functions they shall perform. Furthermore, the project plan shows the potentially useful Gantt chart and the time frame suggesting the duration of each phase to make the project run on time.

Software requirements introduce the software that is particularly important for microcontroller programming. These solutions ensure that the target hardware and software solutions will work adequately when implemented, which ultimately reduces the time needed for software and hardware development and enhances testing and prototyping. Through choosing proper tools, components, and software together with proper development management and strategies, the philosophy of the methodology guarantees successful deployment of Smart Answering Device along with educational and environment sustainability standards.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

Development is led by prototyping, which culminates in the final implementation of The Smart Answering Device. Results from the finalized device, including its performance, functionality and changes made in final stages of development, are described in this section.

After the first design specification, the Smart Answering Device was constructed successfully. All of them together in a working togetherness, in procedures of the assembly and testing phases. The device successfully followed the expected results by reliable performance of answering both objective and subjective questions as per the design requirement.

The key findings include the device's ability to receive accuracy in the inputs from the PS/2 keyboard and the push buttons, and from the LCD; and to interact with the accompanying Android application flawlessly over the Bluetooth HC-05 module. The feedback through the buzzer and LED indicators were clear, and therefore increased user interaction.

Evaluation of performance indicates that the device operates within the desired parameters, with very low latency and high accuracy in data transmission and reception. In addition, any minor testing issues that occurred were addressed by iterative refinements such that the optimum function is obtained.

Consequently, the results validate that the Smart Answering Machine fulfils all the designed requirements and specifications. Implementation of the success is a solid layer for potential future works and extensions.

4.2 Simulation Results

4.2.1 Demo Simulation Using Wokwi

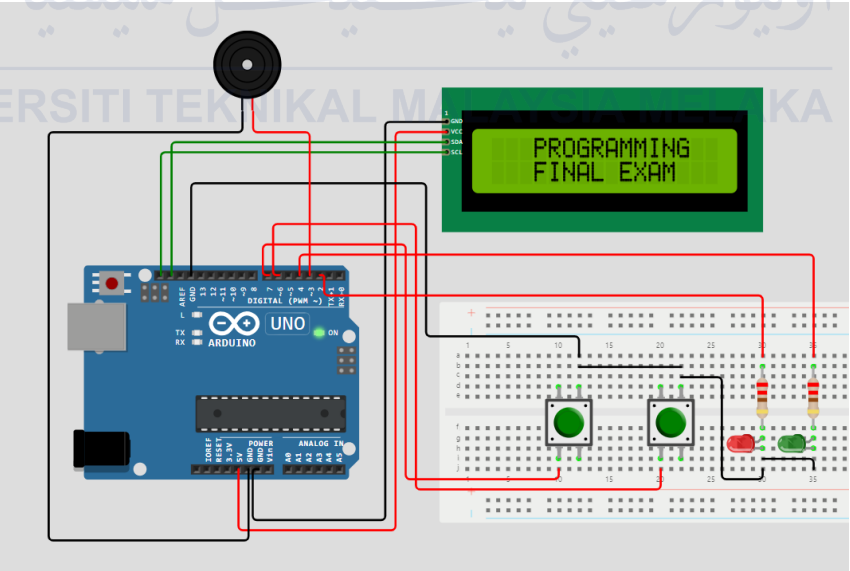


Figure 4.1 Project Demo Simulation Using Wokwi

4.2.2 Demo Simulation Using Tinkercad

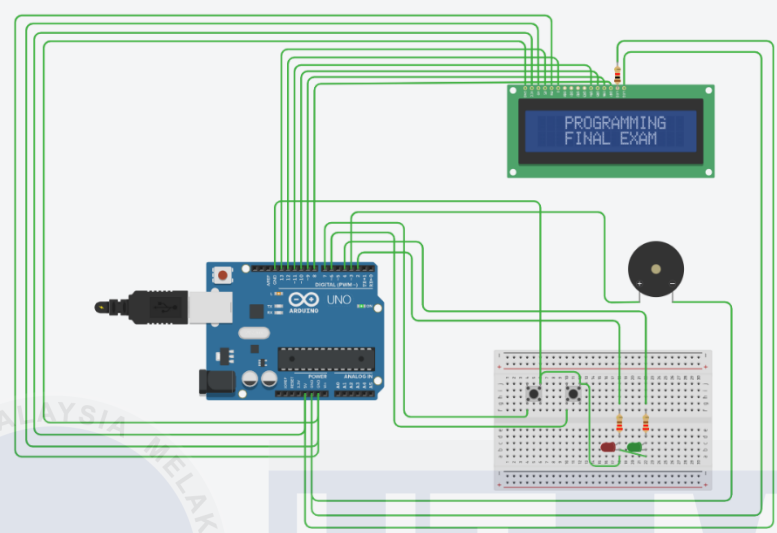


Figure 4.2 Project Demo Simulation Using Tinkercad

4.3 Demo Circuit

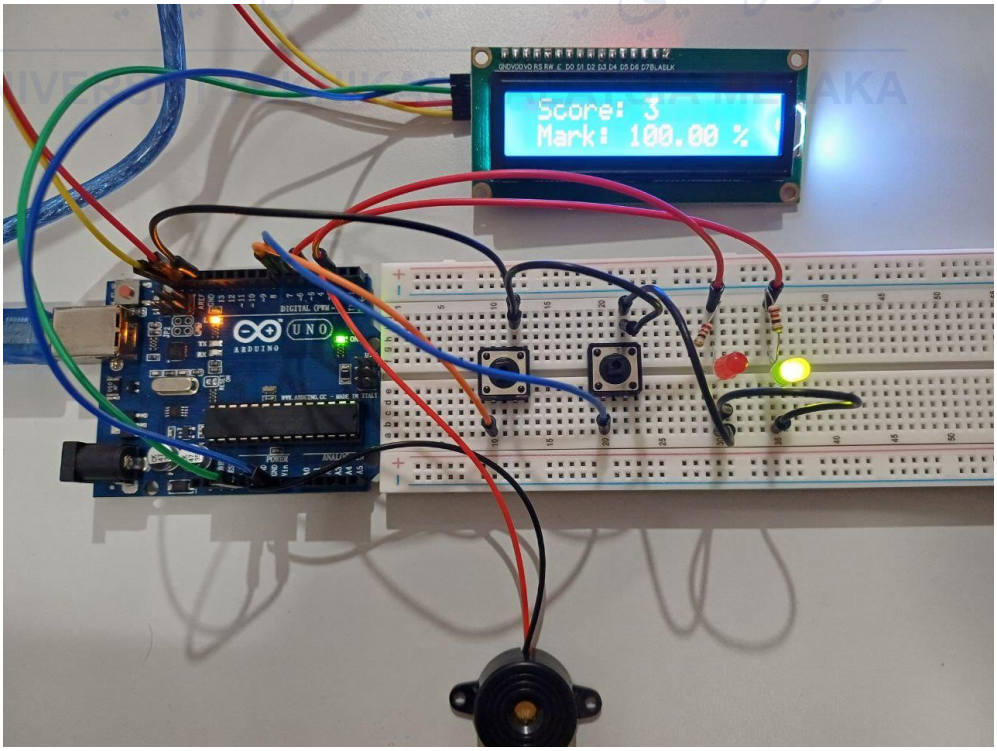


Figure 4.3 Complete Demo Circuit

4.4 Final Prototype

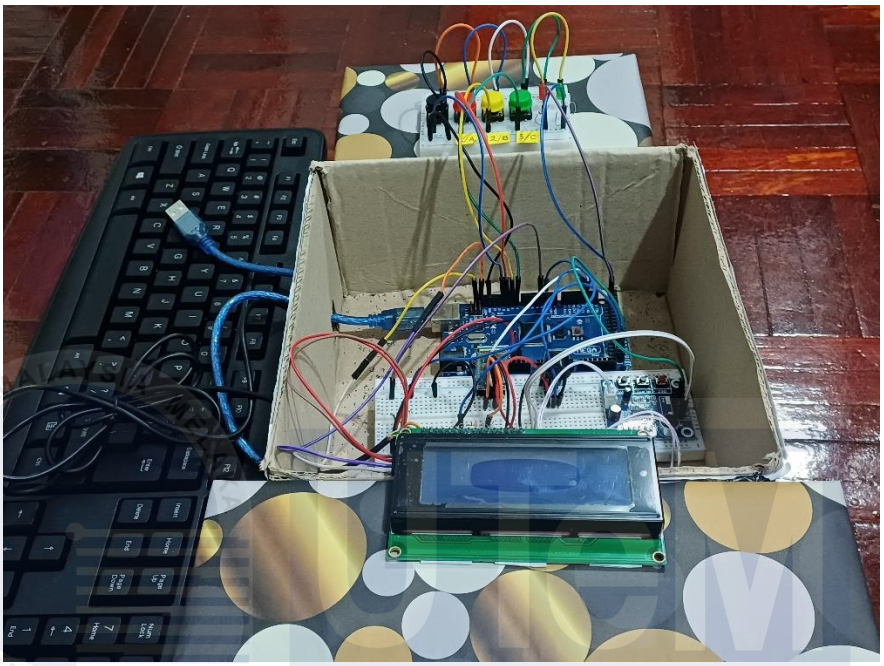


Figure 4.4 Project Final Prototype

4.5 Smart Exam App

4.5.1 Login Page (Main Activity)

Figure below show Main Activity of my android application which serve as the entry point of the application, providing the user interface for the login functionality which require user to enter their username and password before getting permission to access all the functionality inside my application. The activity checks user input when the login button is clicked, verifying the entered credentials. This login page can enhance security and at the same time improve data protection for all the users. If the user inputs an incorrect name or

password, the app will display a toast message which indicates “Wrong password or username”.

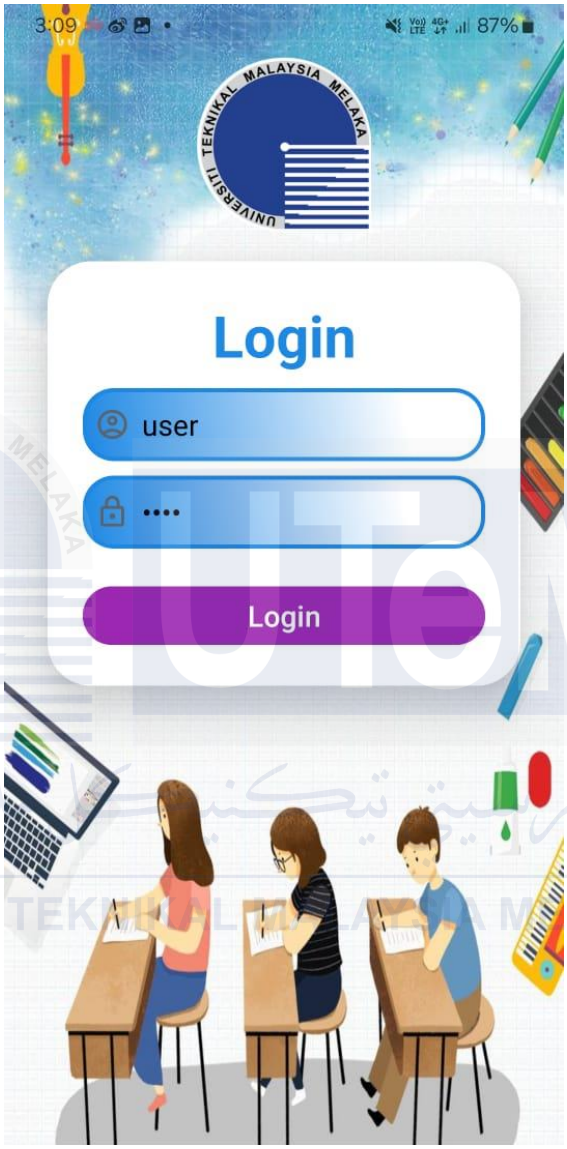


Figure 4.5 Login Page.

4.5.2 Page With All Functionalities (Second Activity)

Figure below shows Second Activity of my application which serves as a central navigation hub by allowing user access to all the functionalities. The activities included in

this page are HC-05 BLUETOOH, OBJ EXAM PAPER, OBJ RESULT, SUB EXAM PAPER, SUB STUDENT ANSWERS and SQLite. It also displays the logo of Smart Exam Apps and an interacting marquee text below the logo.

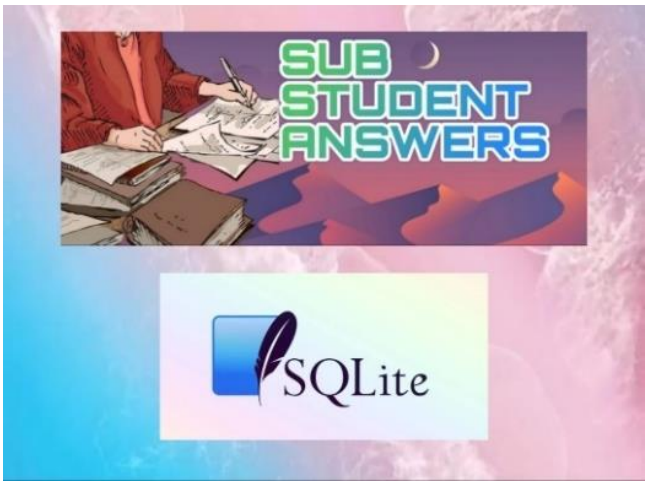


Figure 4.6 All Functionalities of This Application.

4.5.3 Bluetooth Page (Bluetooth Activity)

The Bluetooth Activity figure in this application demonstrates the way Bluetooth connectivity is managed in this application to build communication from Android Device to HC-05 Bluetooth Module. It gives the ability to scan connected devices, to create secure connection with the HC-05 module and to transfer the given data through the ConnectedThread method. It performs the activity checks and makes the requests, at the same time list out paired devices with their details. When successfully connected to the HC-05, data communication will begin, and the information like student's name, matrix number, score, mark and subjective answer is taken and forwarded to the activities further for processing. The activity also comes with user-friendly buttons which are used for searching devices, connecting and refreshing purposes. If our mobile device is not connecting to HC-05 module, it will display a Bluetooth disable logo and the Connect to HC-05 button will be disabled. Users need to enable the Bluetooth service on their mobile device and then press Search Linked BT Devices button to search hc-05 in the surrounding. If the surrounding has a HC-05 Bluetooth, its mac address for example 98:D3:61:F7:1F:D4 will be displayed on

the screen. Lastly, the user simply needs to press the Connect to HC-05 button and the connection will be successful. The screen ultimately will be showing Bluetooth enable's logo.

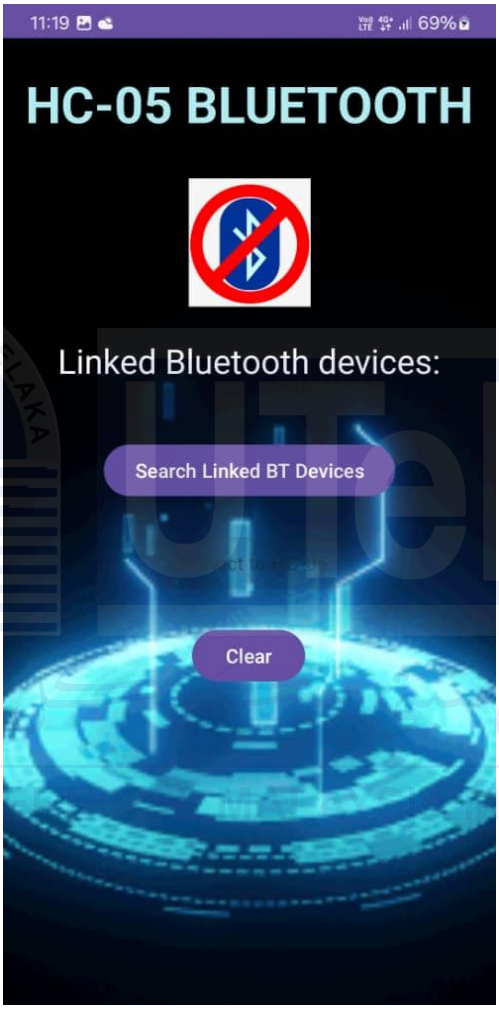


Figure 4.7 Bluetooth Activity Which Manage Bluetooth Connection.

4.5.4 Objective Exam Questions Page (Third Activity)

Figure below show Third Activity of my android application which served as a platform to send all the multiple-choice objective exam questions and their respective answer selections to the Arduino. Lecturers need to set the correct answer for each question by

simply selecting between the radio buttons. The activity provides functionality to save questions locally using SharedPreferences method, send formatted question packets via a Bluetooth connection, and clear input fields for new data. If the data has been saved once, it can be viewed and edited repeatedly even after the app is closed.

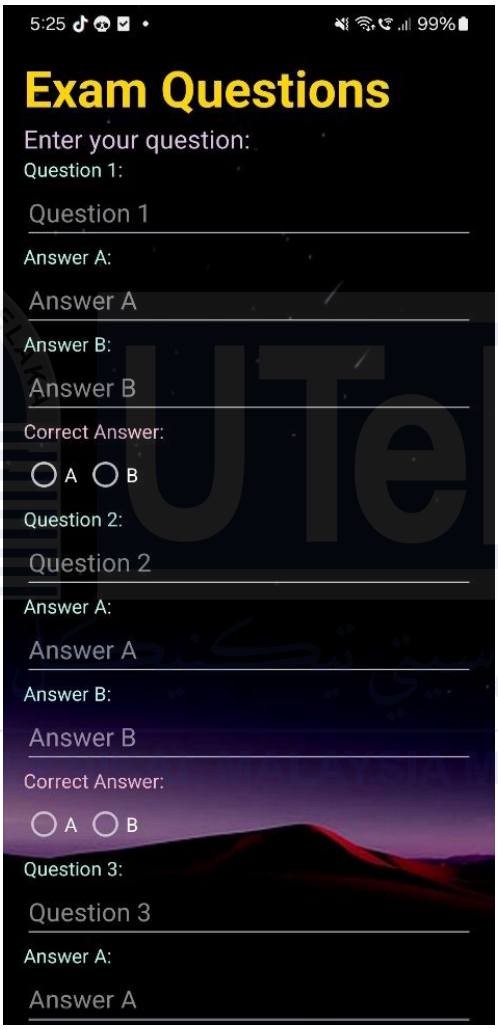


Figure 4.8 Third Activity Which Sent Objective Exam Questions And Answer Selections to The Arduino.

4.5.5 Student Objective Assessment Result Page (Fourth Activity)

Figure below shows Fourth Activity in this application which functions as an interface to display the student's name, matrix number, score and mark after they successfully attend the examination. It manages all the data received from Bluetooth communication. Additionally, the activity retrieves any exam data passed through an Intent and allows the lecturer to save this information to a local database by clicking the "Sent to Database" button.

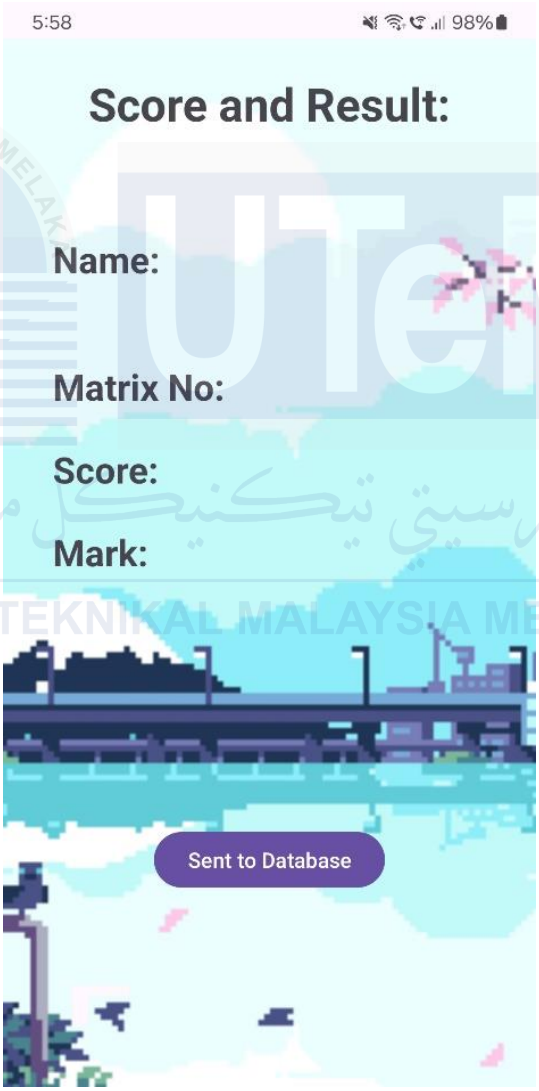


Figure 4.9 Fourth Activity Which Display Student Objective Assessment Result.

4.5.6 Subjective Exam Questions Page (Fifth Activity)

Figure below shows Fifth Activity of my android application, which functions as a platform to send all the subjective exam questions and their pre-set mark to the Arduino Mega 2560. Same with the Fourth Activity, this activity provides functionality to save questions locally using SharedPreferences method, send formatted question packets via a Bluetooth connection, and clear input fields for new data.

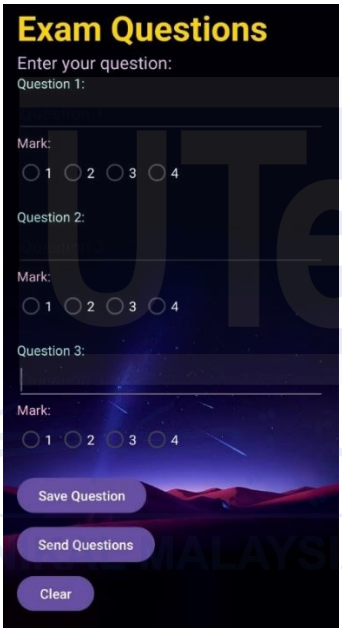


Figure 4.10 Fifth Activity Which Sent Subjective Exam Questions to The Arduino.

4.5.7 Student Subjective Assessment Answers Page (Sixth Activity)

Figure below shows Sixth Activity in this application which functions as an interface to display the student's name, matrix number and their answers after they successfully attend the examination. It also provides functionality for the lecturer to insert all the keywords which act as marking scheme, the app will automatically compare student's

answers with the predefined keywords for each question, identifying how many keywords that the student included in their answer. Lastly, it will calculate scores based on the number of matching keywords. This feature will highly boost the marking process for lecturers, ultimately reduce their workload and increase efficiency. Additionally, the activity retrieves any exam data passed through an Intent and allows the lecturer to save this information to a local database by clicking the “Sent to Database” button. This allows lecturer to retrieve all the student answers from the database to facilitate further marking process.

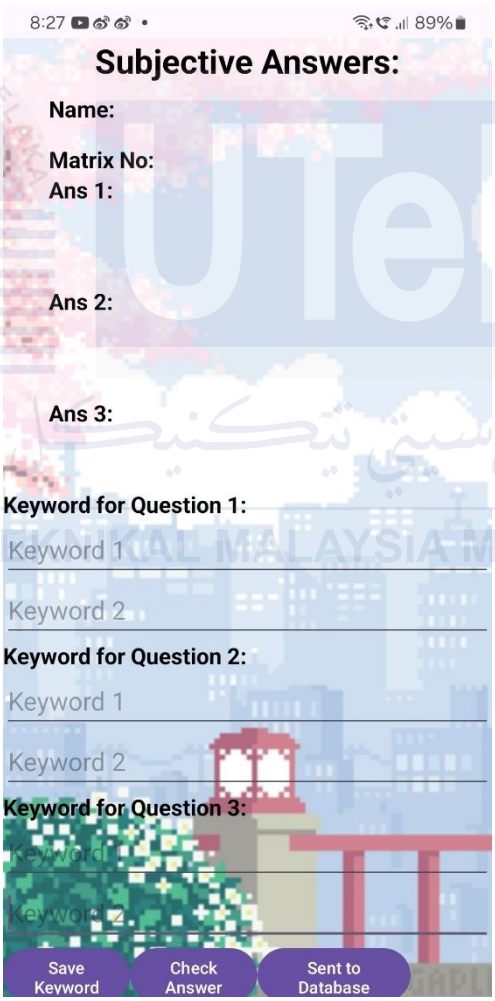


Figure 4.11 Sixth Activity Which Display Student Subjective Assessment Answers and Computed Result.

4.5.8 SQLite Database Page (Database Activity)

The Database Activity acts as a data management GUI, allowing lecturers to view and retrieve stored exam database data in local SQLite database. It fetches records, such as student names, matrix numbers, scores and marks and displays it on a Recycler View using a custom adapter. This data is organized by the activity into arrays, and the user interface is dynamically updated. Furthermore, it provides an easy and user-friendly way of managing and browsing the database content and allows easy viewing of its contents.

4.6 Process Flow

4.6.1 Pre-examination

After we run the coding inside Arduino IDE, the I2C 20x4 LCD will display "Waiting for question from Smart Exam App", indicating it is ready to start the data Transmission process.

Figure 4.12 Arduino Mega 2560 Awaits Exam Questions from The Smart Exam App.

The lecturer must first enable the Bluetooth service on their mobile device, open the HC-05 BLUETOOTH activity and press the “Search Linked BT Devices” button to search the HC-05 Bluetooth module and pair with it. The screen will display the pair module with its corresponding MAC address. Lastly, the lecturer is required to press the “Connect to HC-05” button to establish the connection. When the Bluetooth Socket is created and the connection is built, the Bluetooth disable logo will be changed to Bluetooth enable logo and a toast message “Connect to HC-05” will be displayed.

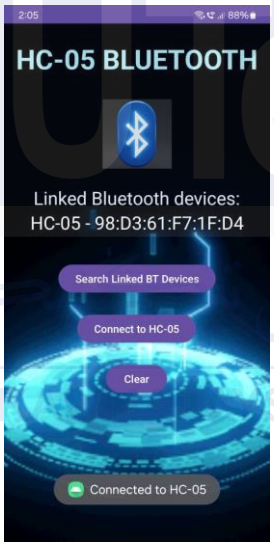


Figure 4.13 Successful Connection to HC-05 Bluetooth Module.

4.6.2 Objective Assessment

After the connection is established, lecturer will navigate to the OBJ EXAM PAPER activity to manage all the exam questions with their respective answer selections. All the questions must be saved by pressing the “Save Question” button and send it to the Arduino by pressing the “Send Questions” button.

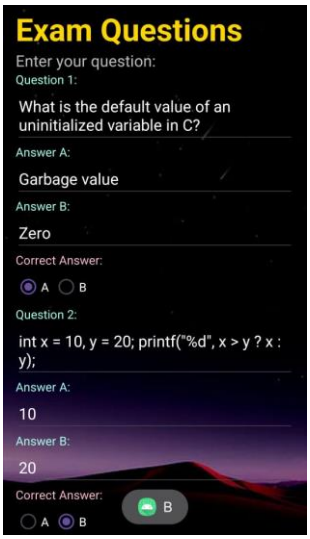


Figure 4.14 Objective Questions and Answer Selections Input.

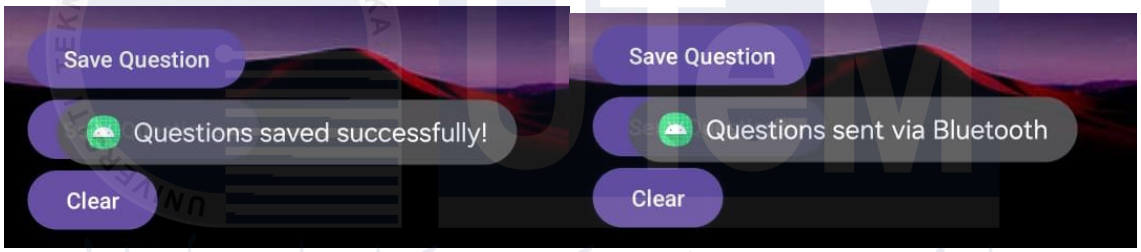


Figure 4.15 Left: Toast Message Indicates Questions Saved Successfully.
Right: Toast Message Indicates Questions Sent Via Bluetooth.

When the Arduino Mega 2560 successfully received all the data without any error, the LCD will display the course name of the exam that will be conducted, which indicates the beginning of the examination.

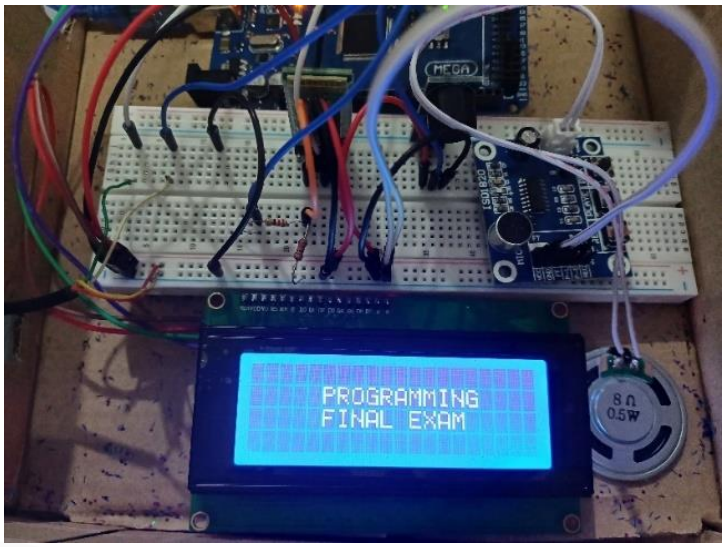


Figure 4.16 Exam's Course Name Appear on Screen Indicates Begin of The Examination.

At this point, the ISD1802 will be triggered and the recording stored inside the module will be played. The audio recording consists of information and instructions to all the candidates and remind them to key in their name and matrix number correctly. Students must enter their name and matrix number and save it by pressing the enter key on the ps/2 keyboard. Figure below show the LCD prompts student to input their name and matrix number.

Figure 4.17 Example of Name input.

Figure 4.18 Example of Matrix Number Input.

Students have now entered the answering session. By pressing the push buttons, students are allowed to select the question that they want to answer first, no need to fix with a specific order. After choosing the desired question to be answered, the LCD will display the question with its both answer selections.

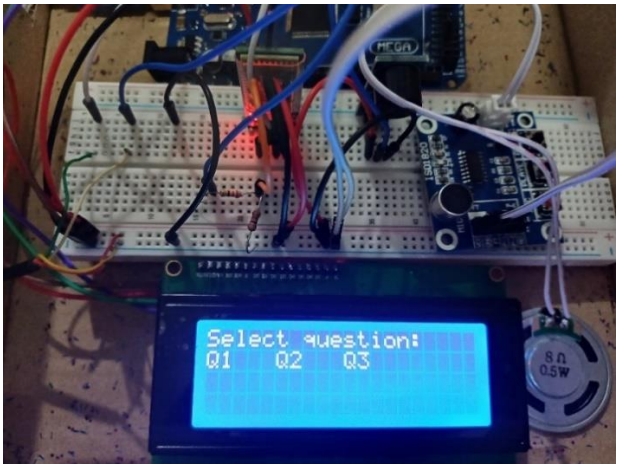


Figure 4.19 Prompt Student to Select Question to be Answered.

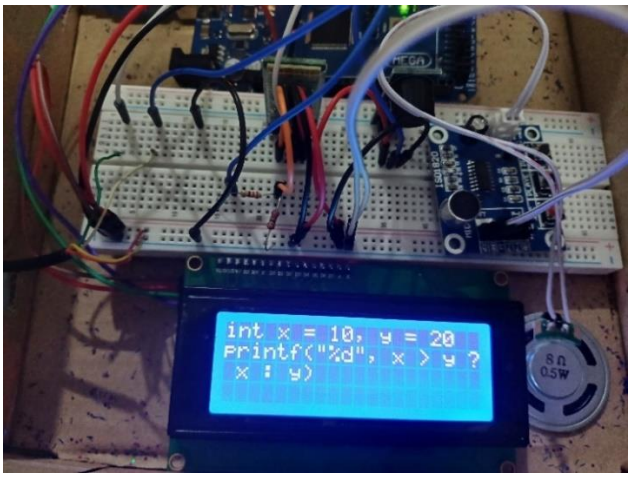


Figure 4.20 Example of Objective Question.

Figure 4.21 Example of Objective Question Answer Selections.

If the student wishes to revisit questions they had already answered, they can simply select the question again. An asterisk symbol (*) will be used to indicate the previously selected answer.

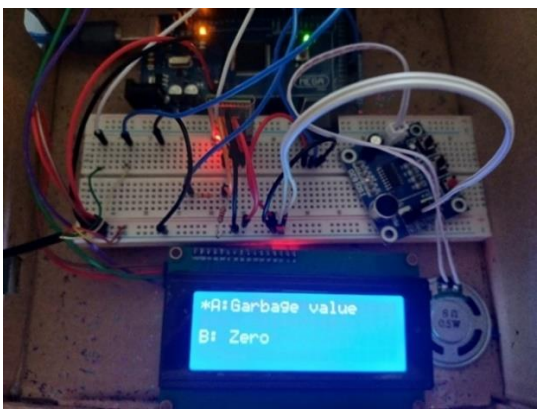


Figure 4.22 Revisit Question For Rechecking or Reanswering Purpose.

4.6.3 Objective Assessment Grading System

After students decide to submit their answers, they can simply press the black color button, and the exam will be terminated. Figure below shows the I2C LCD displays student's result which consist of score and mark. A green LED will be lit up to indicate that the student has passed the exam. (Mark > 40%)

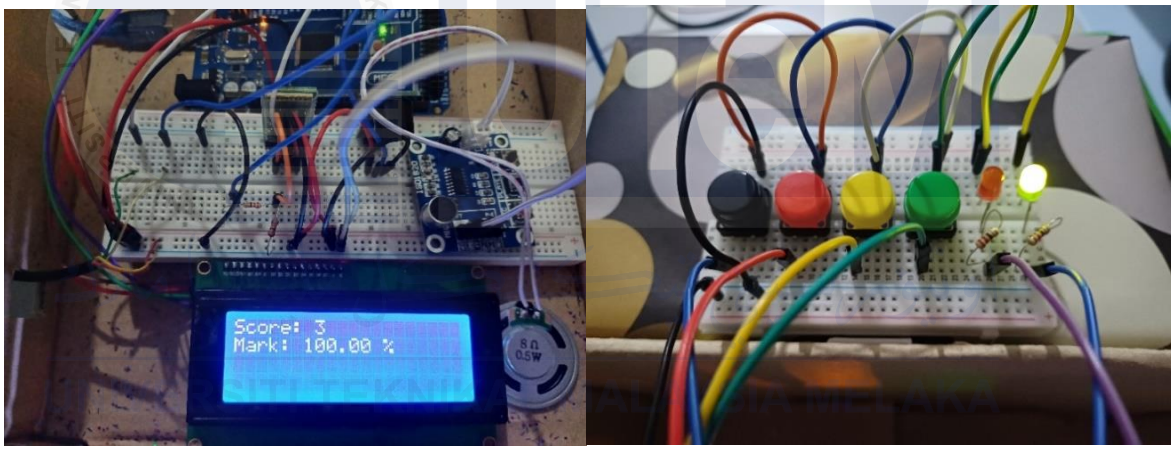


Figure 4.23 Demonstration of Student Passing The Exam.

Figure below shows a red LED will light up to indicate that the student has failed the exam. (Mark < 40%)

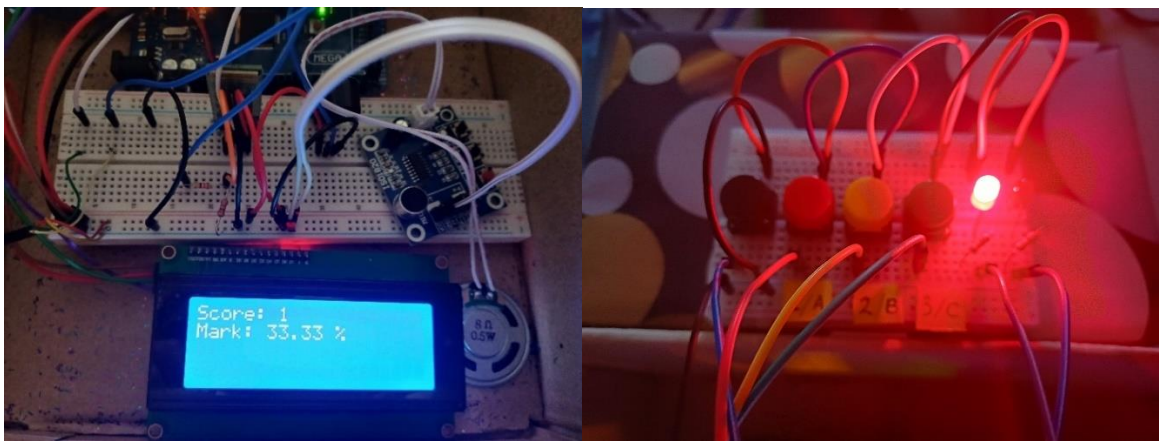


Figure 4.24 Demonstration of Student Failing the Exam.

4.6.4 Objective Assessment Result and Data Process

Figure below shows the student's results for objective assessment successfully sent to the android app from the Arduino.

Figure 4.25 Demonstration of Smart Exam App Display Student Objective Assessment Result.

4.6.5 Subjective Assessment

Similar to the assessment process for objective questions, lecturers need to send all the questions and their corresponding mark to the Arduino through the SUB EXAM PAPER activity.

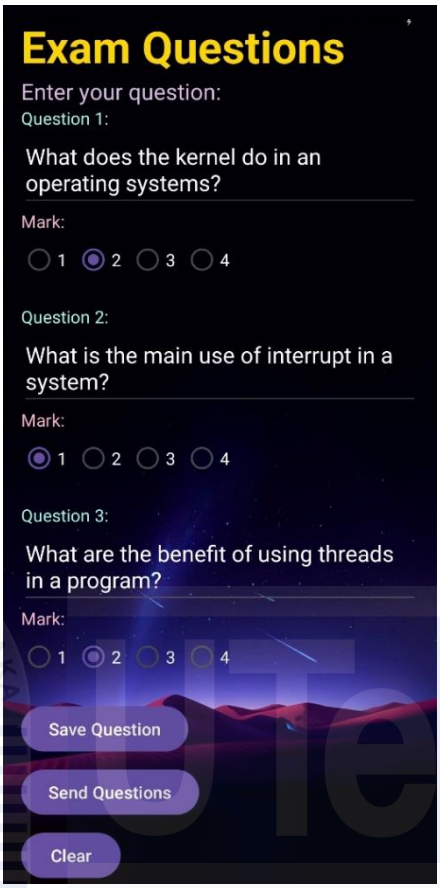


Figure 4.26 Subjective Questions and Mark Input.

When all the data packets have been successfully received by the android app, the system will display the course name and require students to input their name and matrix number. After students press the enter key, they can start attending the exams. Students will select their desired question to be answered, after they study the question carefully, they need to manually input their subjective answer by using the ps/2 keyboard. To save the answer, they can simply press the enter key.

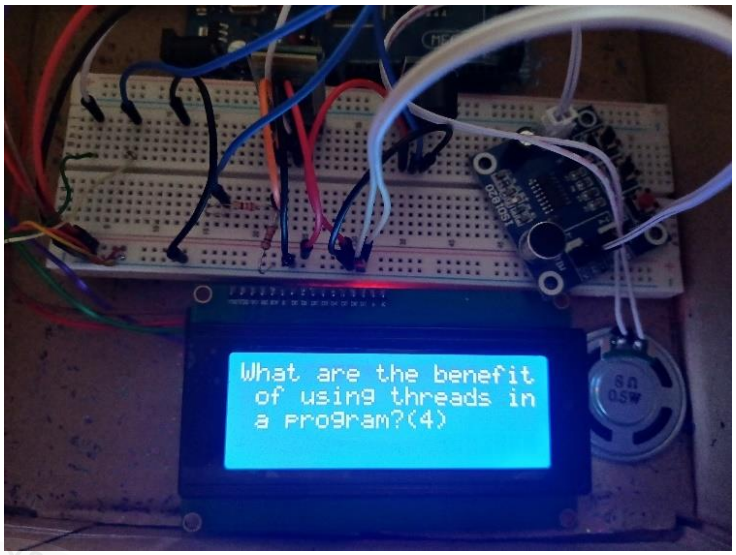


Figure 4.27 Example of Subjective Question.

Figure 4.28 Example of Subjective Question Answering.

4.6.6 Subjective Assessment Result and Data Process

Different when comparing to the objective assessment process, this system does not automatically compute the finalize result of a particular student. However, the system will compare the student with the preset answer scheme which consists of all those keywords that are required for each question. The system will also display the keywords that are found inside the student's answer which can facilitate lecturer further marking process. The system will store all the student information and answers for each question inside the database. Figure below shows the student's answers for subjective assessment successfully sent to the android app from the Arduino. It also shows the results after lecturer presses the "Check Answer" button.

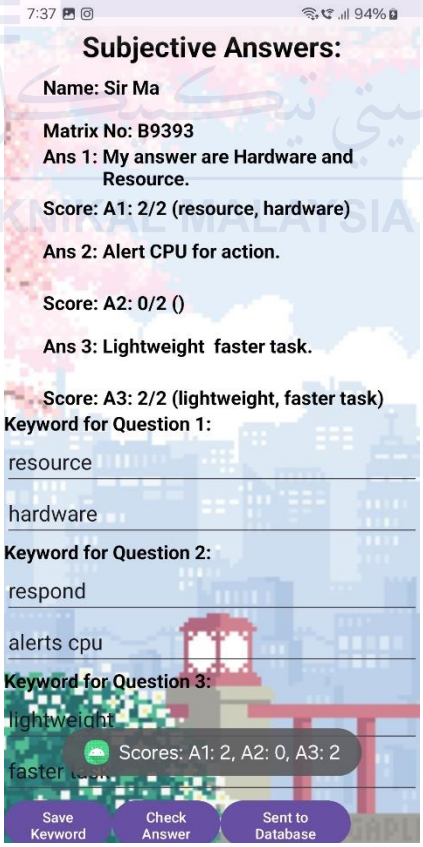


Figure 4.29 Demonstration of Smart Exam App Display Student Subjective Assessment Result.

4.7 Database for Objective and Subjective Assessment

A database named "ExamLibrary.db" had been created by using the SQLite platform. Two tables that consist inside the database are "my_library" and "my_library2". "my_library" table stored all the data related to the objective assessment whereas "my_library2" table stored all the data related to the subjective assessment. Figure below shows the SQLite database that successfully storing all the student's result, name and matrix number for objective assessment.

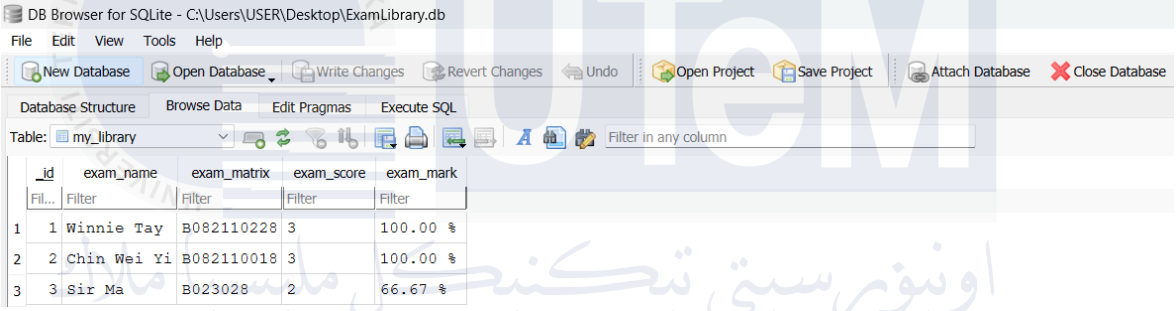


Figure 4.30 SQLite Database for Objective Assessment.

The figure below shows the SQLite database that successfully stores all the student's answers, name and matrix number with the number of matching keyword for each question of subjective assessment .

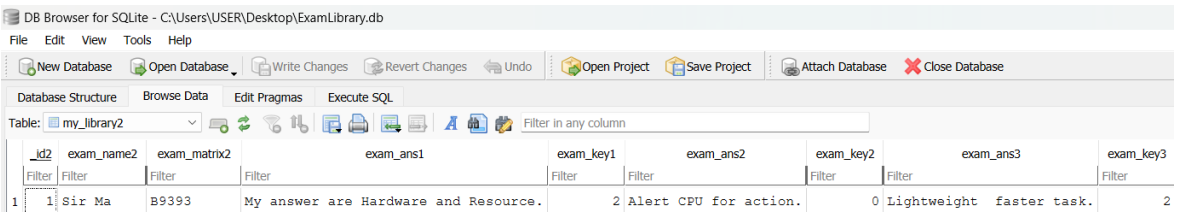


Figure 4.31 SQLite Database for Subjective Assessment.

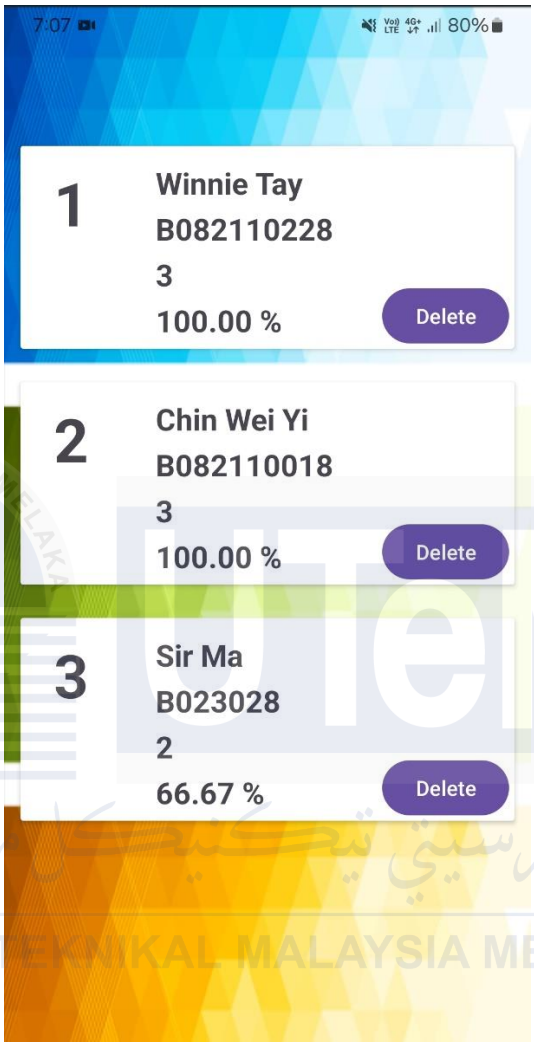


Figure 4.32 Database Activity Which Display All Data Stored Inside SQLite Database.

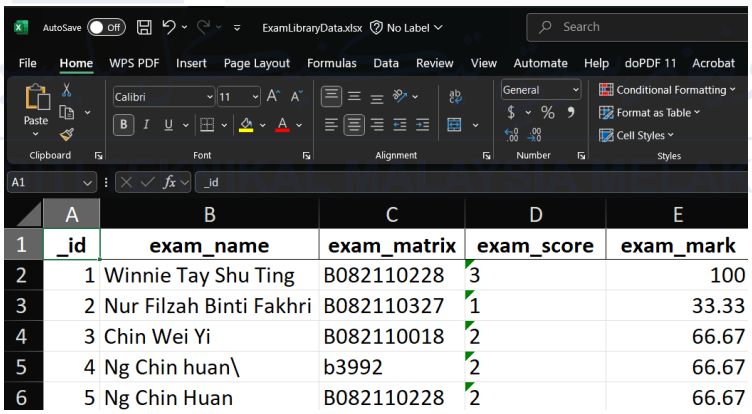
4.8 Buzzer in Timing Control

If the exam is decided to be conducted without the monitoring from the lecturers, the buzzer function will be triggered and set the time limit for the exam. When the exam begins, it will set the StartTime to the current time by using the millis () function. When

EndTime = TotalTime – StartTime, the exam will be terminated and all the result will be transferred to the smart exam app, no matter student had finished answering or not.

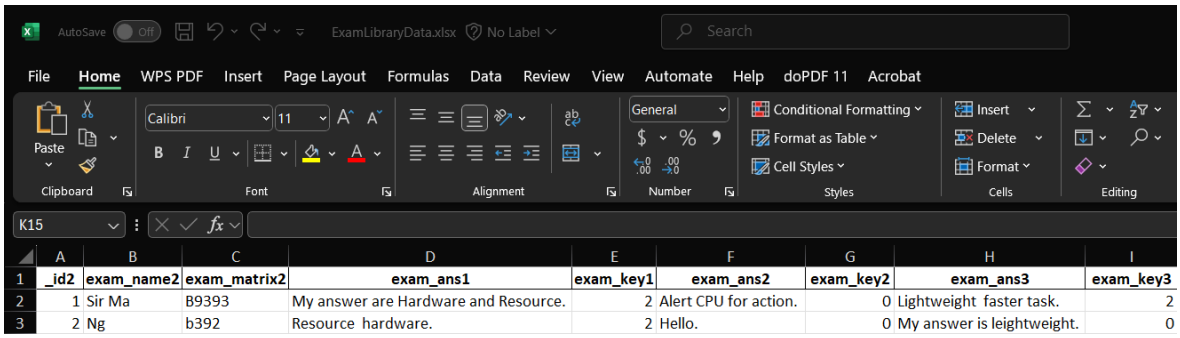
4.9 Excel File and Histogram

To retrieve and manage all the data for further analysis purposes, lecturers can use PyCharm to run the Python code that can automatically generate and open an excel file, at the same time create a histogram that represents student score. Sqlite3 library had been used to interact and connect with the SQLite database. Pandas' library had been used to write the data to an Excel file. Matplotlib.pyplot library had been used to create the graph. Lastly, os library had been used to open the generated files automatically.



	A	B	C	D	E
1	_id	exam_name	exam_matrix	exam_score	exam_mark
2	1	Winnie Tay Shu Ting	B082110228	3	100
3	2	Nur Filzah Binti Fakhri	B082110327	1	33.33
4	3	Chin Wei Yi	B082110018	2	66.67
5	4	Ng Chin huan\	b3992	2	66.67
6	5	Ng Chin Huan	B082110228	2	66.67

Figure 4.33 Transform Data from SQLite Database to Excel File Using PyCharm (Objective Assessment).



	A	B	C	D	E	F	G	H	I
1	_id2	exam_name2	exam_matrix2	exam_ans1	exam_key1	exam_ans2	exam_key2	exam_ans3	exam_key3
2	1	Sir Ma	B9393	My answer are Hardware and Resource.	2	Alert CPU for action.	0	Lightweight faster task.	2
3	2	Ng	b392	Resource hardware.	2	Hello.	0	My answer is leightweight.	0

Figure 4.34 Transform Data from SQLite Database to Excel File Using PyCharm (Subjective Assessment).

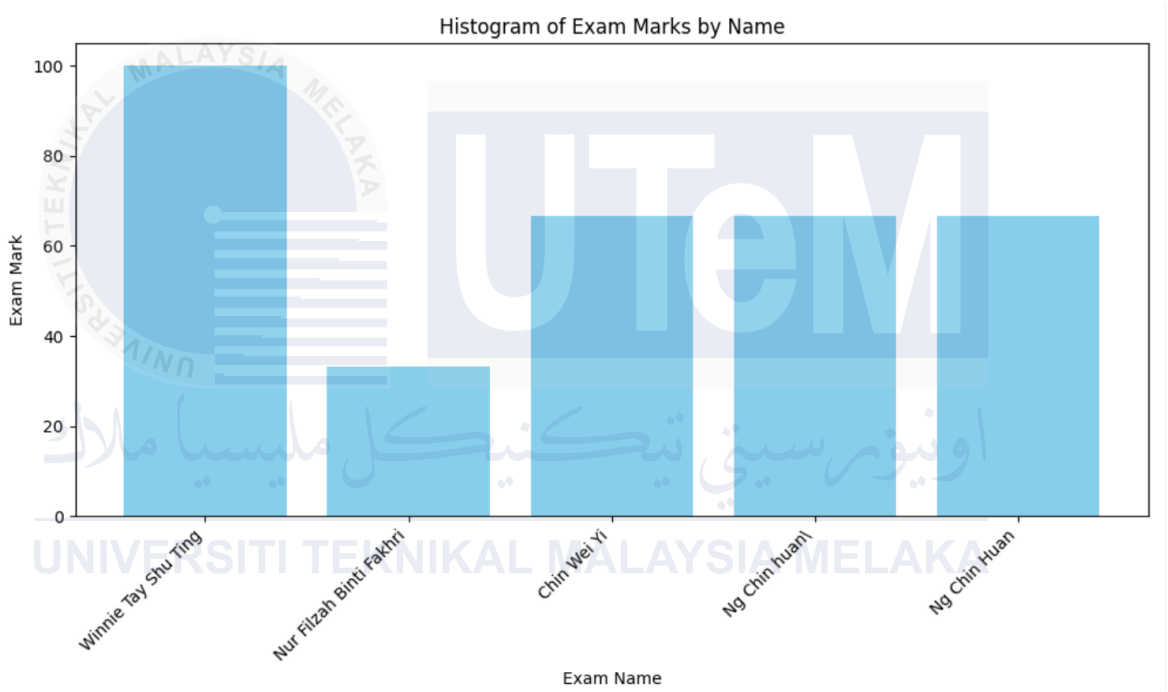


Figure 4.35 Transform Student Mark from SQLite Database to Histogram Using PyCharm.

4.10 Bell Curve of Exam Marks with Performance Categories

A bell curve, or normal distribution, is a simple way to visualize data that naturally clusters around an average. The curve has a smooth, symmetrical shape—like a bell—where most values are close to the middle, and fewer values appear as you move further out. It's a

powerful tool for spotting patterns, like identifying who's performing below average, hitting the average, or excelling. In education or assessments, it gives a clear picture of how students are doing overall and highlights differences in performance levels, making it easier to interpret trends at a glance. To create a bell curve using PyCharm, you can write a Python script with libraries like numpy, scipy, and matplotlib. By defining parameters such as the mean and standard deviation, you can generate a range of values and plot the curve, which can also be saved as an image or embedded into reports for deeper analysis.

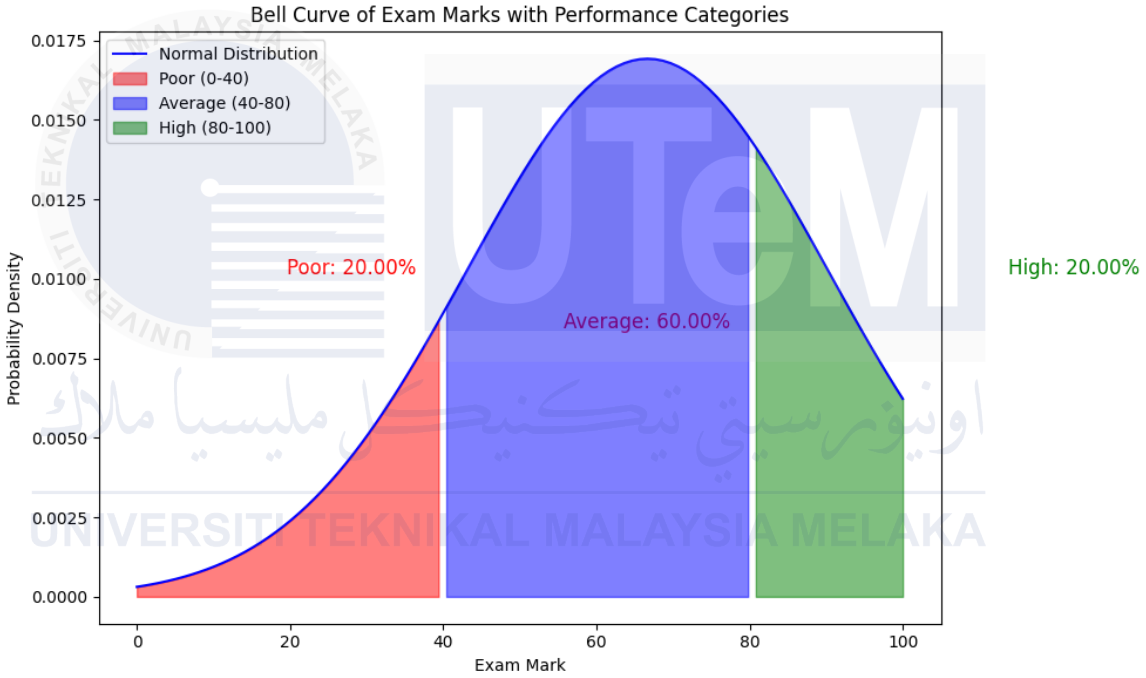


Figure 4.36 Distribution of Exam Marks: Bell Curve Analysis.

4.11 Project Analysis

4.11.1 Analysis 1: The Number of Bytes That Can be Sent by HC-05 Bluetooth

The first analysis that had been performed for this project is to determine how many bytes of character can be transmitted either from Arduino to android app or vice versa. Below illustrates the result obtained.

Table 4.1 Number of Bytes That Can Be Sent Successfully

No.	Number of Bytes Sent	Successful?
1	25	YES
2	50	YES
3	75	YES
4	100	YES
5	101	NO
6	125	NO

Conclusion that I had made for this analysis is HC-05 Bluetooth module can only handle limited number of bytes in a single data transmission. All the data that we want to manipulate is stored inside a temporary storage call buffer. The data transmission limit of a particular module depends on the module's buffer capacity and might vary slightly compared to other modules with different configurations. Each packet that we sent also has a maximum payload size to ensure efficiency and reliability in data transmission. HC-05 Bluetooth module has set the limit between 80-100 bytes as their standard payload size, aligning Bluetooth's standard packet size in Serial Port Profile (SPP) mode. If the data that we want to send exceeds the buffer capacity, it might get truncated or split into parts. Additionally, if the data is sent too fast from the Arduino to the android app, Arduino may fail to fully process each incoming packet before the next packet arrives. This situation can happen especially when the system involves serial parsing.

Solution: Instead of sending all the data that we intended to send from Arduino to the android app in a single packet, we can modify the code to create separate data packets to store different part of the question so that the system can loop through each packet and send it individually via connectedThread.write(packet). This will allow sequential sending, making sure each packet stays within the character limit. A slight delay had also been introduced between each transmission via Thread.sleep(100); so that HC-05 Bluetooth module has sufficient time to process each packet without causing any issue such as buffer overflow.

Before (fail to send data more than 100 bytes):

```
        private void sendQuestion() {
            String dataToSend =
            "Q1:" + question1 + ";A1:" + answerA1 + ";B1:" + answerB1 + ";C1:" +
correctAnswer1 + "\n" +
            "Q2:" + question2 + ";A2:" + answerA2 + ";B2:" + answerB2 + ";C2:" +
correctAnswer2 +"\n" +
            "Q3:" + question3 + ";A3:" + answerA3 + ";B3:" + answerB3 + ";C3:" +
correctAnswer3 +"\n";
            ConnectedThread connectedThread =
BluetoothConnectionManager.getInstance().getConnectedThread();
                if (connectedThread != null) {
                    connectedThread.write(dataToSend);
```

```
            }
        }
```

After (success to send data more than 100 bytes):

```
        private void sendQuestion() {
            ArrayList<String> questionPackets = new ArrayList<>();
            String packet1 = "Q1:" + question1 + ";A1:" + answerA1 + ";B1:" +
answerB1 + ";C1:" + correctAnswer1;
            questionPackets.add(packet1);
            String packet2 = "Q2:" + question2 + ";A2:" + answerA2 + ";B2:" +
answerB2 + ";C2:" + correctAnswer2;
            questionPackets.add(packet2);
            String packet3 = "Q3:" + question3 + ";A3:" + answerA3 + ";B3:" +
answerB3 + ";C3:" + correctAnswer3;
            questionPackets.add(packet3);
            ConnectedThread connectedThread =
BluetoothConnectionManager.getInstance().getConnectedThread();
            if (connectedThread != null) {
                for (String packet : questionPackets) {
                    connectedThread.write(packet);
                    try {
                        Thread.sleep(100);
                    } catch (InterruptedException e) {
                        e.printStackTrace();
```

```
            }
        }
    }
}
```

4.11.2 Analysis 2: Bluetooth Connection Attempts vs. Successful Connections

Figure below visualizes the number of Bluetooth connection attempts compared to the number of successful connections by using bar chart. The x-axis represents “Attempts” and “Successes” whereas the y-axis represents the count of each event to be occurred. In 100 samples taken, only 7 times Bluetooth connection fail had been recorded indicate high success rate of Bluetooth connection. Below are several reasons that may cause the connectivity issue:

1. Device not in range, the device is too far from the HC-05 Bluetooth module. Bluetooth technology is normally designed with a limited access range, around 10 meters.
2. Device busy or off, another connection might be interfered with the Bluetooth connection. The target device could be turned off.
3. Incorrect pairing, incorrect mac address can cause the connection attempt to be unsuccessful. The pairing information which is corrupted or outdated might be another reason.
4. Environmental interference, there exist physical obstacles between the mobile device and the Bluetooth module. Electronic devices such as Wi-Fi routers which use 2.4 GHz frequency in operation can create interference.

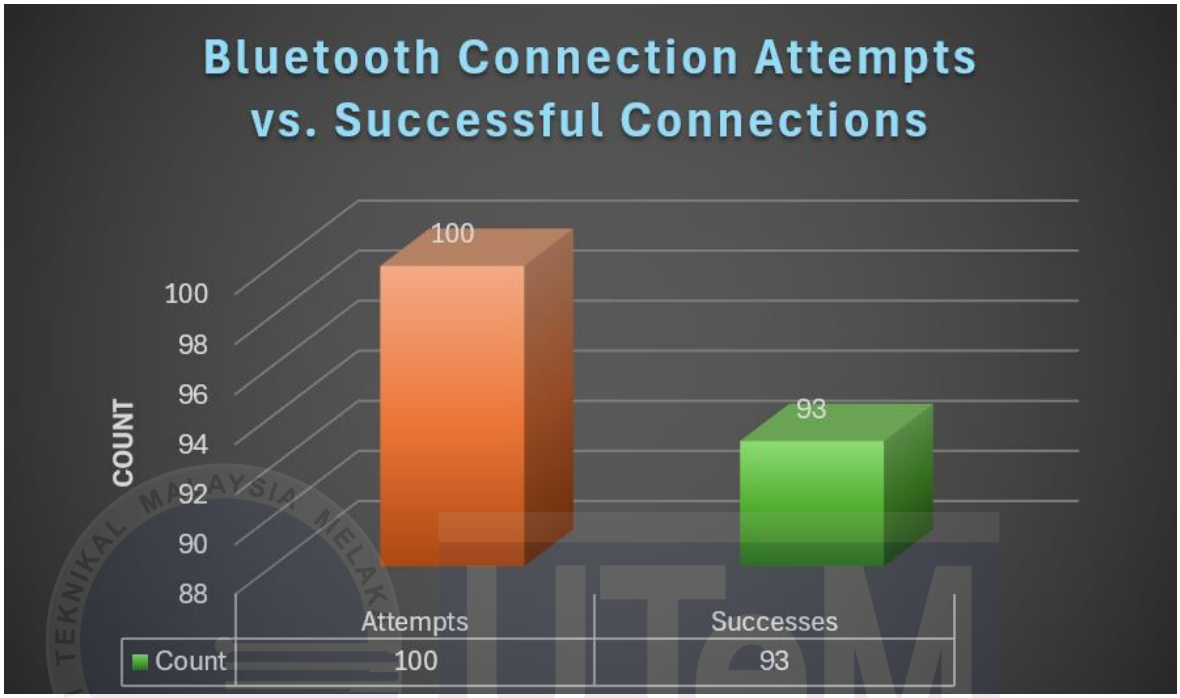


Figure 4.37 Bar Chart of Bluetooth Connection Attempts vs. Successful Connections.

4.11.3 Analysis 3: Transmission Time from Android App to Arduino.

Below is the analysis on time taken for Arduino Mega 2560 to receive three objective exam questions with both answer selections from the android app. Data input with different length of byte had been used to perform this analysis.

Table 4.2 Transmission Time from Android App to Arduino VS Number of Bytes

No.	Number of Bytes	Start Receiving Time (ms)	End Receiving Time (ms)	Total Receiving Time (ms)
1	144	27801	28917	1116
2	296	24951	26190	1239
3	416	94856	96194	1338
4	566	64834	66249	1415

5	710	73284	74765	1481

In sum, the longer the number of bytes sent from android app to Arduino, the more time required for the Arduino to wait for the input data.

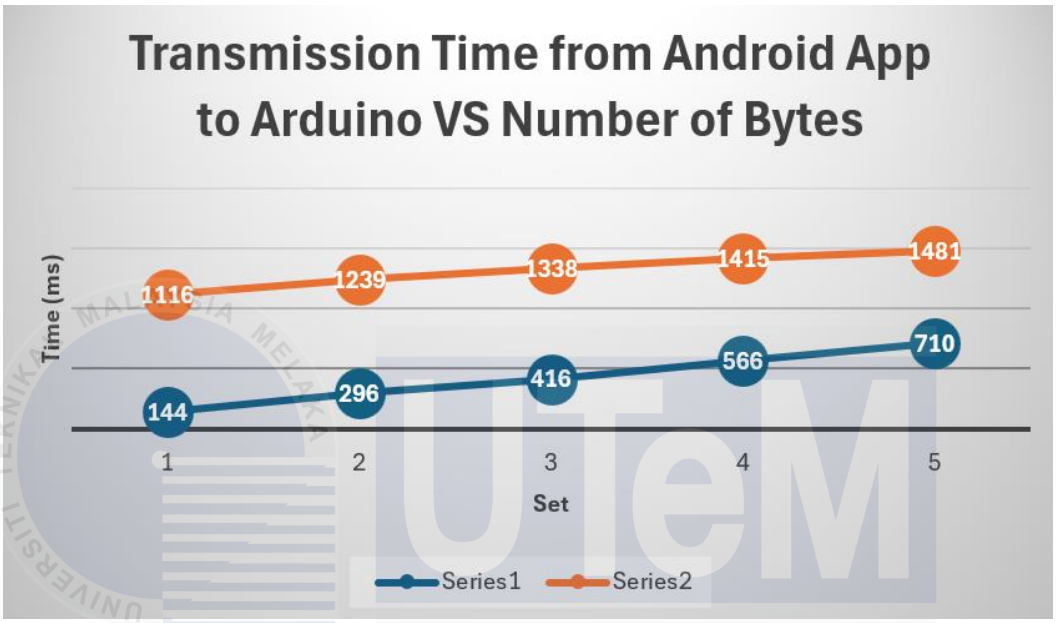


Figure 4.38 Transmission Time from Android App to Arduino VS Number of Bytes.

Code to record the transmission time:

```
unsigned long startReceivingTime = 0;
unsigned long endReceivingTime = 0;


void loop() {
  if (Serial1.available()) {
    startReceivingTime = millis(); // Record the start time of transmission
    String receivedData = Serial1.readStringUntil('\n');
    endReceivingTime = millis(); // Record the end time of transmission
    Serial.print("Received via Bluetooth: ");
```

```
        Serial.println(receivedData);


        unsigned long totalReceivingTime = endReceivingTime - startReceivingTime; //
Calculate duration


          Serial.println("Start Receiving Time (ms): ");
          Serial.println(startReceivingTime);
          Serial.println("End Receiving Time (ms): ");
          Serial.println(endReceivingTime);
          Serial.println("Transmission Time (ms): ");
          Serial.println(totalReceivingTime); // Print the transmission time

        parseQuestions(receivedData); // Parse received questions
        delay(1000);
    }
```


4.11.4 Analysis 4: Bluetooth Permission Outcomes

Figure below show a pie chart which displays the proportion of Bluetooth permission outcomes. Each segment represents the percentage of either granted or denied permissions. Based on the result obtained, 97% of the Bluetooth permissions are granted whereas 3% are denied. Below are several reasons that may cause the Bluetooth permission to be denied:

1. Permission Denied by User, user may accidentally deny the Bluetooth permission when prompted by the app. This might be due to the user lacking understanding why permission is needed.
2. Missing Runtime Permission Request, this is because in modern operating system of mobile devices, certain permissions must be requested by apps at runtime rather than relying solely on installation time permissions.
3. Operating Systems Restrictions, some OS poses a stricter rule on Bluetooth permissions handling, making it require additional action from the users.

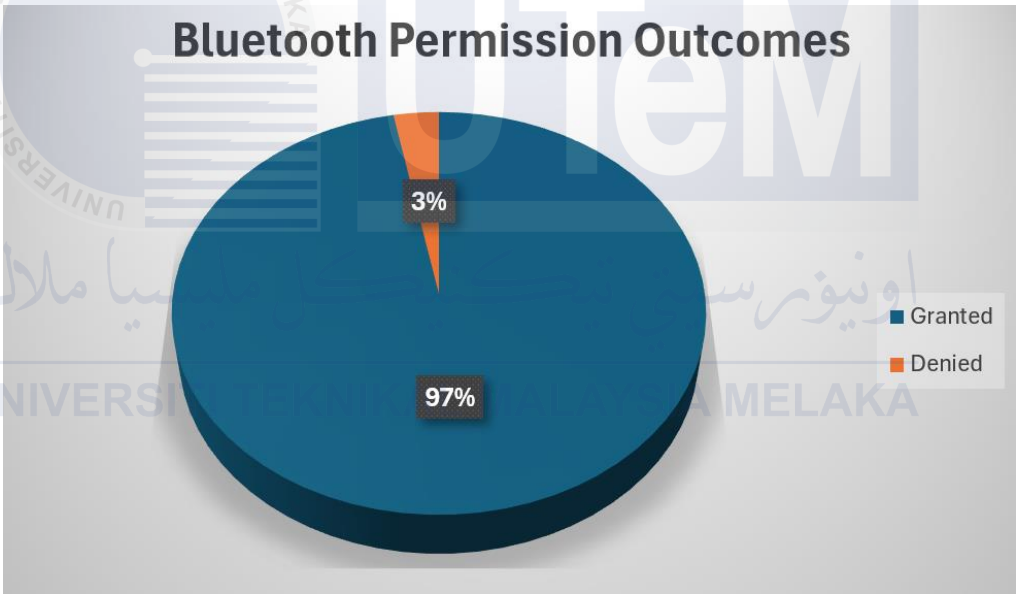


Figure 4.39 Pie Chart of Bluetooth Permission Outcomes.

4.12 Summary

The chapter on preliminary results presents an informative summary of the functionality and performance of the Smart Answering Device prototype. Beginning with the initial setup, the chapter showcases how the device interacts with users, starting from displaying the course name and prompting students to input their personal details on the I2C

LCD screen. It then goes on to show the working of operation during the exam phase where objective questions are presented in sequences and answers are selected with the help of push buttons. The reliability of the device in its ability to provide verbal feedback, by employing LEDs to give immediate results. Further, incorporating a buzzer to manage time by reminding students at certain exam times improves the overall performers' experiences. Overall, this chapter showcases a complete demo to identify the specific successful working functions as well as the further enhancements or modifications which might be needed to fulfil the aims and objectives of the device.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In a nutshell, it can be concluded that the proposed Smart Answering Device advances educational institution's perspective by making examination methods more sustainable and efficient. The implementation of this project has effectively reduced the environmental problem caused by the usage of the conventional papers-based examination and at the same time, improved on the authenticity and effectiveness of the methods of testing. The approach utilized in the project sought to make a clear effort to incorporate eight principles of sustainable development through selection of appropriate energy efficient components, consideration of impacts of the used material throughout their life cycle, and effective use of resources with a view of reducing the amount of electronic waste within the project. The project would have recorded some significant levels of accomplishment from conceptual design to implementation of basic hardware as well as testing. The improvements in the future will be the fine-tuning of the software details by using Arduino Integrated Development Environment, as well as the examination on the availability of simulation software by Tinkercad and Wokwi. Subsequently, the Smart Answering Device offers potential to being beneficial not just in academic settings but also in driving sustainability endeavors as well as encouraging the advancement of technology in evaluation procedures.

5.2 Potential for Commercialization

The Smart Answering Device offers significant potential for commercialization by providing an innovative solution to modernize examination processes. Its ability to replace traditional paper-based exams with a more sustainable and efficient method appeals to educational institutions at all levels, from primary schools to universities. The widespread implementation of this device across schools and higher education institutions could not only transform the educational landscape but also contribute positively to the economy. Large-scale adoption would generate demand, leading to increased production, job creation, and economic growth, particularly in the technology sector.

This device's environmental benefits, such as reducing paper waste, align with the growing emphasis on sustainability, making it an attractive option for institutions aiming to meet eco-friendly goals. Its customizable and scalable design ensures adaptability across various educational settings, enhancing its appeal. By eliminating the recurring costs associated with paper exams, including printing and storage, the Smart Answering Device offers a cost-effective solution with durable, reusable hardware that promises long-term savings.

The integration with an Android app and the potential for advanced features like data analytics, remote monitoring, and real-time feedback further enhance its value proposition. These features provide educators with tools for data-driven decision-making and personalized learning, adding a layer of innovation to the educational process. Moreover, strategic partnerships with educational technology companies, government education

departments, and sustainability-focused organizations could facilitate widespread adoption, driving the growth of the technology industry.

Overall, the Smart Answering Device has the potential to boost the economy by fostering technological advancement, creating new opportunities in the educational technology sector, and positioning itself as a vital tool for modernizing assessment methods while promoting sustainability and efficiency.

5.3 Future Works

Looking ahead, several enhancements and expansions can be made to further develop the Smart Answering Device. One significant improvement is the integration of artificial intelligence (AI) for marking subjective questions. This AI system could analyze student responses more accurately by recognizing patterns and keywords, providing automated grading with greater precision and reducing the lecturer's workload. Additionally, upgrading the LCD to a graphical LCD will allow the display of more complex questions that include diagrams or graphs, enhancing the versatility and visual clarity of the exam content.

Future iterations of the device could also incorporate more sophisticated data analytics features within the Android app, allowing educators to track and analyze student performance over time. This could lead to more personalized feedback and targeted learning interventions. Furthermore, expanding the device’s connectivity options to include Wi-Fi or

cloud integration would enhance its versatility, enabling remote monitoring and data storage, and making it suitable for online or hybrid learning environments.

Another potential area of development is the inclusion of additional languages and localization features to cater to a broader range of educational settings globally. This would make the device more accessible and user-friendly for diverse populations. Lastly, integrating more advanced security measures to protect sensitive student data and exam information will be crucial as the device scales for broader use.

In summary, the future development of the Smart Answering Device will focus on AI-driven subjective question marking, enhanced graphical display capabilities, improved connectivity, data analytics, expanded localization, and robust security, ensuring that it continues to meet the evolving needs of educational institutions and contributes to the advancement of educational technology.

REFERENCES

[1] V. Kumar, M. Manwal, S. Gupta, and P. Patil, "JOURNAL OF CRITICAL REVIEWS CONTRIBUTION IN ENVIRONMENT AND REVENUE GENERATION BY RECYCLING OF EDUCATIONAL INSTITUTION'S WASTE PAPERS."

[2] R. W. Gorte, "CRS Report for Congress Deforestation and Climate Change," 2010. [Online]. Available: www.crs.gov

[3] C. A. Silva, G. Santilli, E. E. Sano, and G. Laneve, "Fire occurrences and greenhouse gas emissions from deforestation in the Brazilian Amazon," *Remote Sens (Basel)*, vol. 13, no. 3, pp. 1–18, Feb. 2021, doi: 10.3390/rs13030376.

[4] R. Rifin *et al.*, "EXAMWIZ: A DEVELOPMENT AND IMPLEMENTATION OF AN ANDROID BASED EXAMINTION," *J Fundam Appl Sci*, vol. 10, no. 6S, p. 965, 2018, doi: 10.4314/jfas.v10i6s.46.

[5] A. H. Azahar *et al.*, "Looping board: Development of an electronic educational quiz board that test student knowledge on laplace transform for electrical circuit modelling," *International Journal of Engineering Trends and Technology*, vol. 69, no. 3, pp. 64–68, Mar. 2021, doi: 10.14445/22315381/IJETT-V69I3P212.

[6] A. H. Azhar *et al.*, "E-Transform: Development of an electronic educational quiz board for learning high-school's mathematical transformation," *International Journal of Engineering Trends and Technology*, vol. 69, no. 5, pp. 128–132, May 2021, doi: 10.14445/22315381/IJETT-V69I5P218.

[7] A. Faiz, Z. Abidin, and A. Adam, "Resducational Kit The Development of An Electronic Quiz Board That Test Engineering Students Knowledge on Resistors Concept in Electrical Circuit Optimization View project Study on The Position Tracking Control of a Small Scale Unmanned Armoured Vehicle View project," 2019. [Online]. Available: https://www.researchgate.net/publication/333773683

[8] M. L. Still and J. D. Still, "Contrasting Traditional In-Class Exams with Frequent Online Testing," *Journal of Teaching and Learning with Technology*, vol. 4, no. 2, pp. 30–40, Dec. 2015, doi: 10.14434/jotlt.v4n2.13481.

[9] C. P. Newhouse, "COMPUTER-BASED EXAMS IN SCHOOLS: FREEDOM FROM THE LIMITATIONS OF PAPER?," Asia-Pacific Society for, 2013.

[10] F. S. Irwansyah, J. Yanto, W. D. I. Azis, and Kelvin, "Optimization of Empty Fruit Bunches (EFB) as a solution to deforestation as a result of the exploitation from the paper industry in Riau of conferences," in *IOP Conference Series: Materials Science and Engineering*, Institute of Physics Publishing, Dec. 2018. doi: 10.1088/1757-899X/434/1/012189.

[11] "Modernising assessment: the use of Web 2.0 for formative and summative Modernising assessment: the use of Web 2.0 for formative and summative assessment assessment." [Online]. Available: https://hdl.handle.net/2134/4543.

[12] G. Ocak and G. Karakuş, "Undergraduate students' views of and difficulties in online exams during the COVID-19 pandemic."

[13] R. Fendler, D. Beard, and J. Godbey, "A Robust Examination of Cheating on Unproctored Online Exams," *Electronic Journal of e-Learning*, vol. 22, no. 5, pp. 26–38, May 2024, doi: 10.34190/ejel.22.5.3173.

[14] A. W. Muzaffar, M. Tahir, M. W. Anwar, Q. Chaudry, S. R. Mir, and Y. Rasheed, "A systematic review of online exams solutions in e-learning: Techniques, tools,

and global adoption," *IEEE Access*, vol. 9. Institute of Electrical and Electronics Engineers Inc., pp. 32689–32712, 2021. doi: 10.1109/ACCESS.2021.3060192.
[15] "Ebook_Ayala_The_8051_Microcontroller".
[16] A.-E. Bogen and V. Wollan, "AVR Enhanced RISC Microcontrollers."
[17] L. Louis, "Working Principle of Arduino and Using it as a Tool for Study and Research," *International Journal of Control, Automation, Communication and Systems*, vol. 1, no. 2, pp. 21–29, Apr. 2016, doi: 10.5121/ijcacs.2016.1203.
[18] "CONCEPTS OF PROGRAMMING LANGUAGES."
[19] K. A. Kadiran *et al.*, "e-FLOWCHART: AN ELECTRONIC EDUCATIONAL QUIZ BOARD THAT TEST STUDENT KNOWLEDGE ON C PROGRAMMING CONCEPT USING FLOWCHART COMMAND," vol. 13, no. 23, 2018, [Online]. Available: www.arpnjournals.com
[20] Z. O. Mohammad, Z. A. Amar Faiz, H. M. Syahrul, K. A. Nur Dalila, and N. Ismail, "E-logic trainer kit: Development of an electronic educational simulator and quiz kit for logic gate combinational circuit by using arduino as application," *International journal of online and biomedical engineering*, vol. 15, no. 14, pp. 67–77, 2019, doi: 10.3991/ijoe.v15i14.11410.

APPENDICES

Appendix A Gantt Chart PSM 1

NO	TASK	WEEK													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Title Planning and Research														
2.	Proposal Writting														
3.	Submission of Proposal (Title & Synopsis)														
4.	PSM1 Briefing & Information Literacy Programme														
5.	Thesis Briefing														
6.	Introduction Writing														
7.	Progress Work 1 (W6)														
8.	Literature Review														
9.	Methodology														
10.	Progress Work 2 (W12)														
11.	Preliminary Result Writing														
12.	Conclusion Writing														
13.	Submission of BDP1 Report														
14	BDP1 Presentation														
15.	Project Demo														

Appendix B Gantt Chart PSM 2

NO	TASK	WEEK													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Planning and Research														
2.	Define Requirements and Features														
3.	Android App Development														
4.	Bluetooth Management Development														
5.	Ps/2 Keyboard Integration														
6.	Android App Designing														
7.	Final Prototype Designing														
8.	Database Setup														
9.	Results and Discussion														
10.	Functional Testing														
11.	Project Analysis														
12.	Conclusion and Recommendations														
13.	Poster Designing														
14.	PSM 2 Draft Submission														
15.	Presentation and Thesis Submission														