UTM
UNIVERSITI TEKNOLOGI MALAYSIA

UNIVERSITI TEKNOLOGI MALAYSIA

AUTOMATED OBJECTIVE AND SINGLE-WORD ANSWER QUESTIONS MARKING USING HANDWRITTEN TEXT RECOGNITION

Presented By: Wai Jia Wen (A21EC0139)
Supervisor: Dr. Pang Yee Yong

SECV3032 -01 Graphics and Multimedia Software Project I | Session 2023/2024 2

Video link: https://youtu.be/79G8tjLRbHE

Innovating Solutions

PROBLEM BACKGROUND

01

The manual marking process for handwritten quizzes or tests is time-consuming and tiring (Rowtula, Oota & Jawahar, 2019)

Delay in providing feedback to students

02

Student's poor handwriting or way of answering difficult to read (Oche, 2014)

Educators distracted and make marking mistakes

Objective and single-word answer questions are relatively simple and direct to mark (limited and precise answers) compared to open-ended questions like short answers, essay, and diagram drawing questions that have more variety in answering (Süzen, Gorban, Levesley & Mirkes, 2020).

By automating the marking of objective and single-word answer questions, educators can focus on reviewing other assessments, which speeds up the marking process.

Optical Mark Recognition (OMR) is a well-established automated marking system but limited to evaluating hand-marked answers for objective questions. The SPM English listening that includes objective and single-word answer questions cannot be fully assessed using OMR technology alone.

PROJECT AIM

"Develop automated objective and single-word answer questions marking mobile application using handwritten text recognition."

PROJECT OBJECTIVES

01

To **identify the requirement** of the SPM English Listening Test assessments marking by secondary school English teachers and tutors.

02

To **design and develop** a marking mobile application that can mark handwritten objective and single-word answer questions for the SPM English Listening Test.

03

To **test and evaluate** the accuracy of the marking mobile application in marking the students' SPM English Listening Test assessments.

PROJECT SCOPES

- ☑ The application is single-user based and uses computer vision to recognize handwritten answers to simulate the human marking process.
- ☑ The application is restricted to mark objective and single-word answer questions only.
- ☑ The single-word answer must match the answer scheme provided by the educators.
- ☑ The target users for this application are educators, especially secondary school English teachers and tutors.
- ☑ The application will use the smartphone camera to scan the students' answer sheets and generate marks.

LITERATURE REVIEW

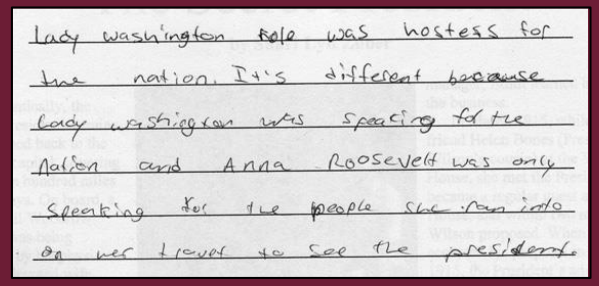
SPM ENGLISH LISTENING

"SPM is the national secondary school leaving examination for Malaysians ("Seating for Public Exam", 2024). According to Alia (2021), the format of the SPM English exam has been altered in 2021, divided into reading, writing, speaking, and listening papers. The **listening** test **weighs 25% of the total SPM English marks** and has a **30-question format** divided into **four parts**.

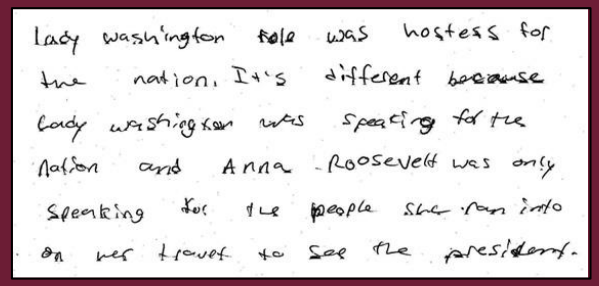
Part 1 until Part 3 has **multiple choice questions** (20 questions; Part 1: 7 questions, Part 2: 8 questions, Part 3: 5 questions), while **Part 4** has **single-word answer questions** (10 questions)."

LITERATURE REVIEW

IMAGE PRE-PROCESSING



Scanned Gray-scale Image (Srihari et al., 2008)



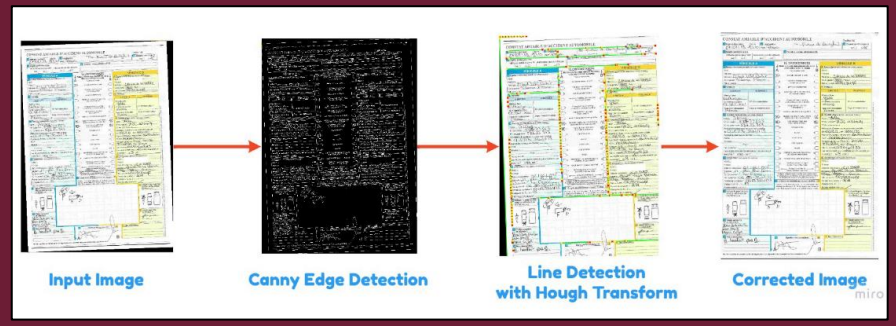
Rule–lines Detected Using the Hough Transform and Removed (Srihari et al., 2008)

01 RULE-LINE REMOVAL

The guidelines on answer sheets are intended to ensure neat handwriting but can hinder text recognition, so need to be removed.

02 DE-SKEW

In some cases, the image acquired might skew slightly. De-skewing is applied to straighten the skewed text lines.



De-skewed Image (Benchekroun, 2022)

03 BINARIZATION

Binarization divides an image into foreground (black) and background (white) pixels, aiding document analysis by simplifying complex backgrounds, varying font colors and sizes, and handling stains and wrinkles.

LITERATURE REVIEW (COMPARISON BETWEEN TEXT DETECTION AND SEGMENTATION METHODS)

Text Detection / Segmentation Models	Strengths	Limitations
Corner Point Detection	Simple step. Accurately locate text regions in documents. Works well with various image conditions. High performance.	Struggle with text in large fonts. Trouble with illustrations with highlighted corners. No layout information like paragraphs and lines.
CNN-based Approach	Works well with multi-oriented handwritten text detection. Precisely locate text regions using bounding box and pixel links. Efficiently segment text into text-lines.	Computational complexity for training.
Projection Profile	Efficiently segment text into lines, words and characters. Involved pre-processing steps for better enhancement.	More complex than corner point detection. Sensitive to noise. Potential inaccuracy with overlapped and connected characters.

LITERATURE REVIEW (COMPARISON BETWEEN OCR MODELS (Google, n.d.; Gribomont, 2023; Tesseract-Ocr, n.d.; Thammarak et al., 2022))

Features	Google Cloud Vision API	Tesseract OCR
Advantages	More accurate text recognition. No need extra development or training. Support more programming languages. Support more input format.	Free. More accurate layout detection. Can be used in command-line. Only need to download the software and no initial set up.
Disadvantages	Cost required if exceeds 1000 pages monthly. Layout detection issues. Need to follow a series of steps to set up the project and access API key.	Less accurate text recognition. Support lesser programming languages. Support lesser input format. Need extra development or training for better accuracy.

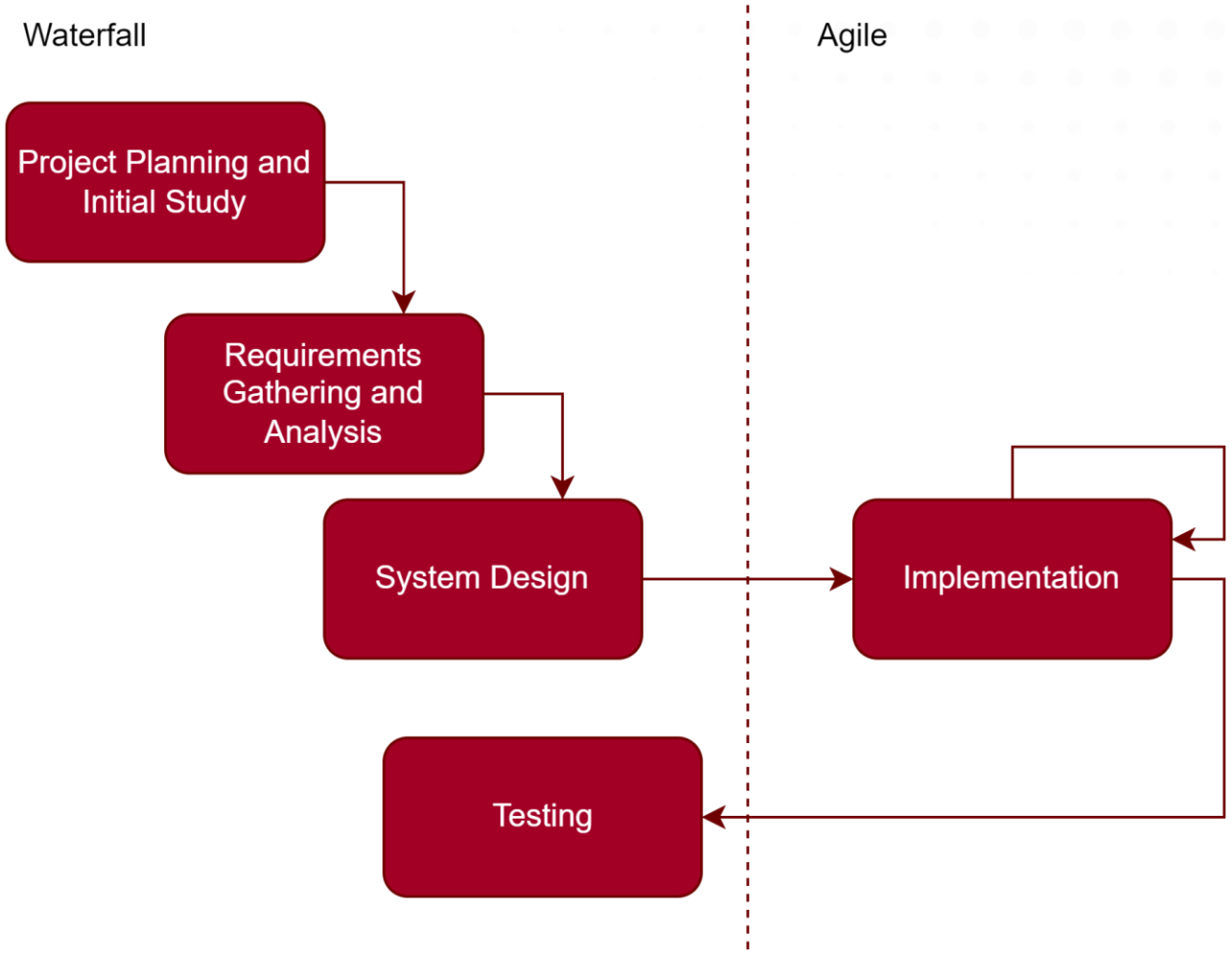
Google Cloud Vision API

Tesseract OCR

LITERATURE REVIEW (COMPARISON BETWEEN EXISTING SYSTEMS)

System	Strengths	Limitations
ZipGrade LLC (n.d.)	User-friendly interface. Support forms creation and customization. Real-time marking. Offer detailed analytics on student performance. Can export quiz results.	Limited support for non-multiple choice questions, primarily designed for multiple choice assessments. Limited answer choices, support maximum 5 lettered answer choices per question only.
Lu et. al (2021)	Cost effective, do not need extra answer cards. No limit where the students can fill in the answer. Able to grade handwritten alphabets and numerical answer.	Incorrect recognition due to scribbles. No user-friendly interface.
Shaikh et al. (2019)	Able to grade handwritten alphabets and numerical answer.	Require portable scanner. Segmentation based on predefined answer sheets template, segmentation failed on slightly tilted images.

SYSTEM DEVELOPMENT METHODOLOGY



CHOSEN METHODOLOGY

SYSTEM DEVELOPMENT METHODOLOGY

SUMMARY OF EACH PHASE

PROJECT PLANNING AND INITIAL STUDY

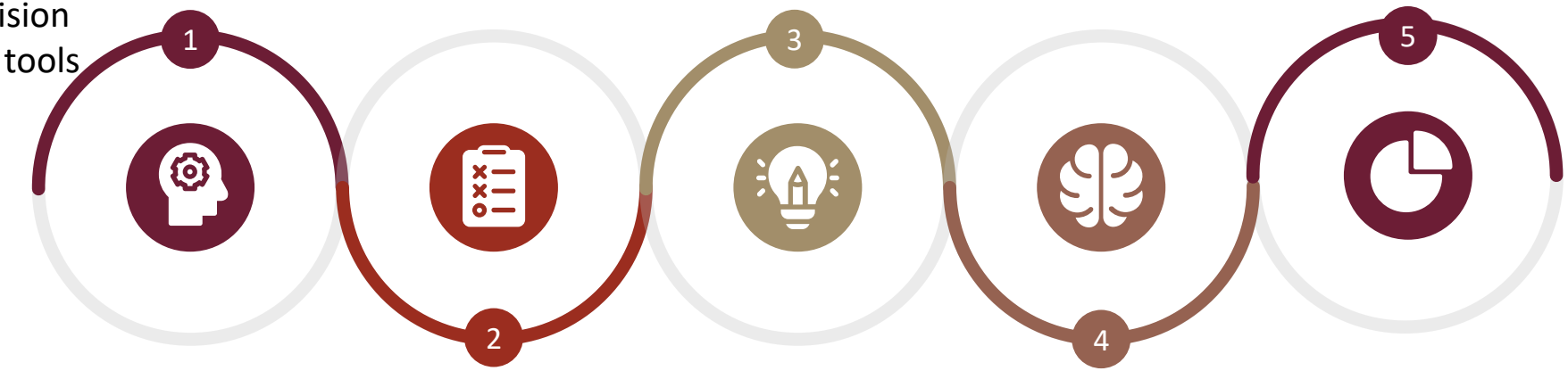
Project Gantt chart
Define objectives and scope
Conduct background study
Propose solution
Study of computer vision techniques and OCR tools

SYSTEM DESIGN

Use case diagram
Use case description
Architecture design
Database design
User Interface (UI) design

TESTING

Pivot Testing
Heuristic Evaluation



REQUIREMENTS GATHERING AND ANALYSIS

Survey through Google Forms
Analyze the survey results with Microsoft Power BI
Elicit functional & non-functional requirements

IMPLEMENTATION

Iterative, sprint-based development

SYSTEM DEVELOPMENT METHODOLOGY
(DEVELOPMENT TOOLS AND ENVIRONMENT)

01 Flutter

02 python™

03 Flask

04 OpenCV

05 VISUAL STUDIO CODE

06 ANDROID STUDIO

07 GitHub

08 Firebase

SYSTEM DEVELOPMENT METHODOLOGY

HARDWARE AND SOFTWARE REQUIREMENTS

HARDWARE REQUIREMENTS

Hardware	Justification
Laptop	Research, documentation, coding
Android Phone	Emulator, project implementation

SOFTWARE REQUIREMENTS

Software	Justification
Visual Studio Code	Main IDE for project development
Android Studio	Required for emulator
Jira	Project management tools for scrum
Draw.io	Create Unified Modelling Language (UML) diagram
MockFlow	Create low-fidelity prototype for UI
Microsoft Word	Report documentation

REQUIREMENTS ANALYSIS & DESIGN

KEY ASPECTS OF THE SURVEY RESULTS

01

Survey (13 questions) was available for **2 weeks**, received **25 responses** (**17 teachers, 68% and 8 tutors, 32%**) from secondary school English teachers and tutors in Johor and other states.

02

The **average listening assessment given a year** is **10** approximately and the **mean time to mark one listening answer sheet** is **95.4 seconds**.

03

The results indicate that 84% of the respondents **expressed a willingness to use an automated marking system if available**, despite all respondents never use one before and more respondents (36%) consider the task of marking listening assessments to be quick and not tiring.

04

88% of respondents also expect that **automating the marking** of listening assessments will **speed up the provision of feedback** to students.

REQUIREMENTS ANALYSIS & DESIGN

KEY ASPECTS OF THE SURVEY RESULTS

05

The **most demanded functionalities** are generating a document of the list of students' scores (88%), record the score after marking (84%) and upload answer scheme document (64%).

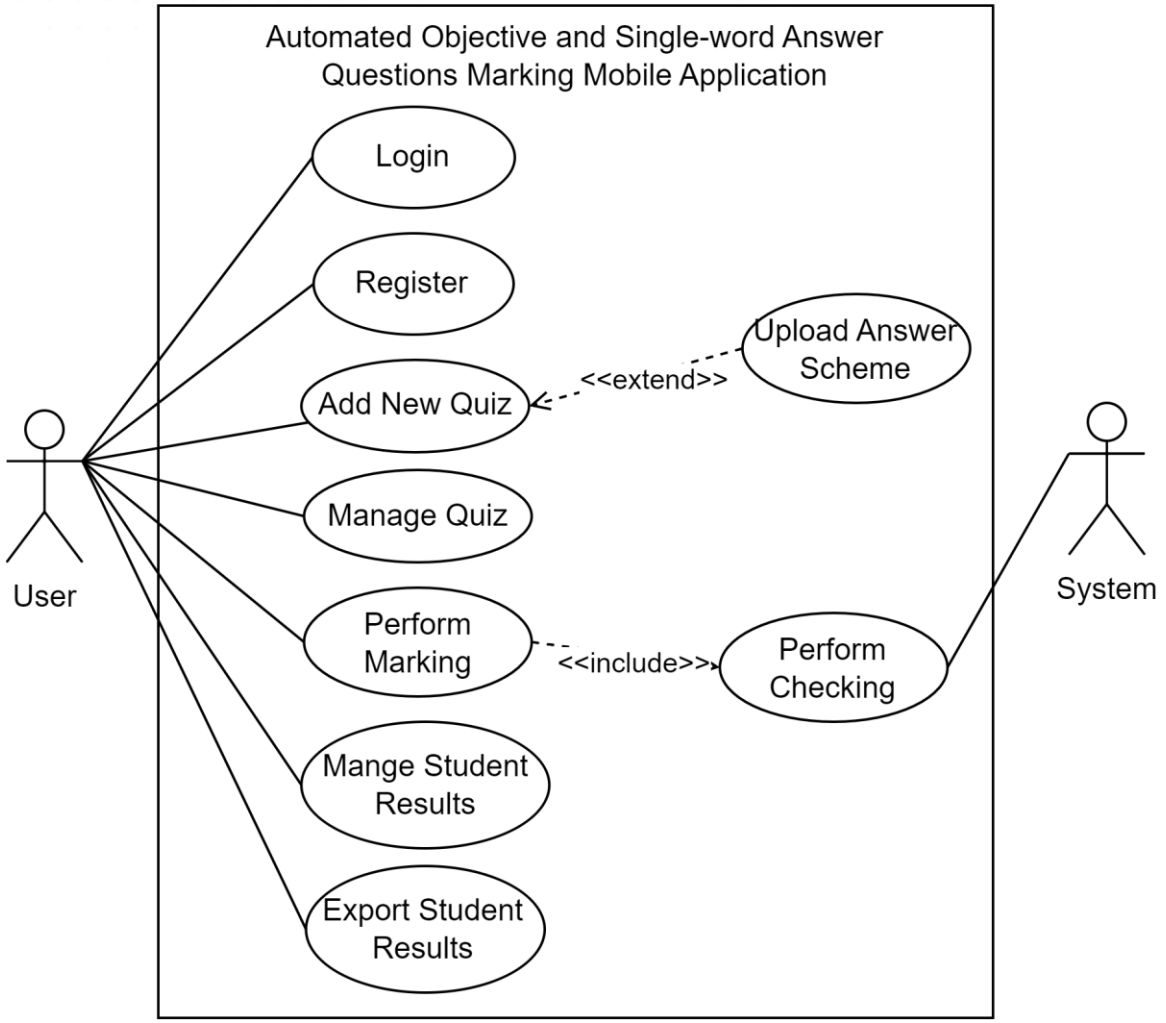
06

The **formatted answer sheets** are **commonly used by teachers** (15 out of 17, 88.24%) for efficient marking.

07

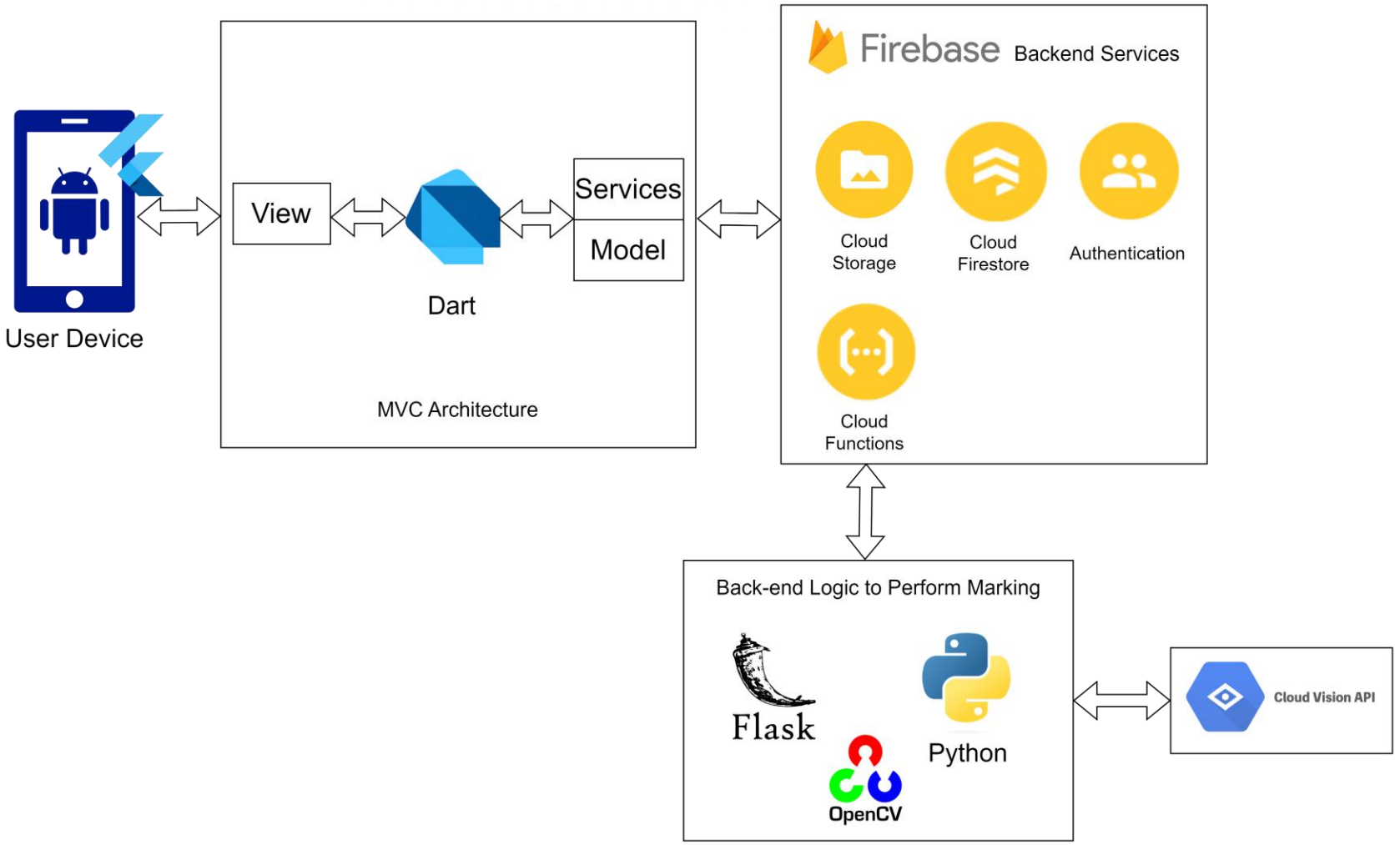
Most tutors think that preparing and printing the formatted sheets is troublesome (6 out of 8, 75%) and **prefer** the **non-formatted sheets** (6 out of 8, 75%).

REQUIREMENTS ANALYSIS & DESIGN



USE CASE DIAGRAM

REQUIREMENTS ANALYSIS & DESIGN

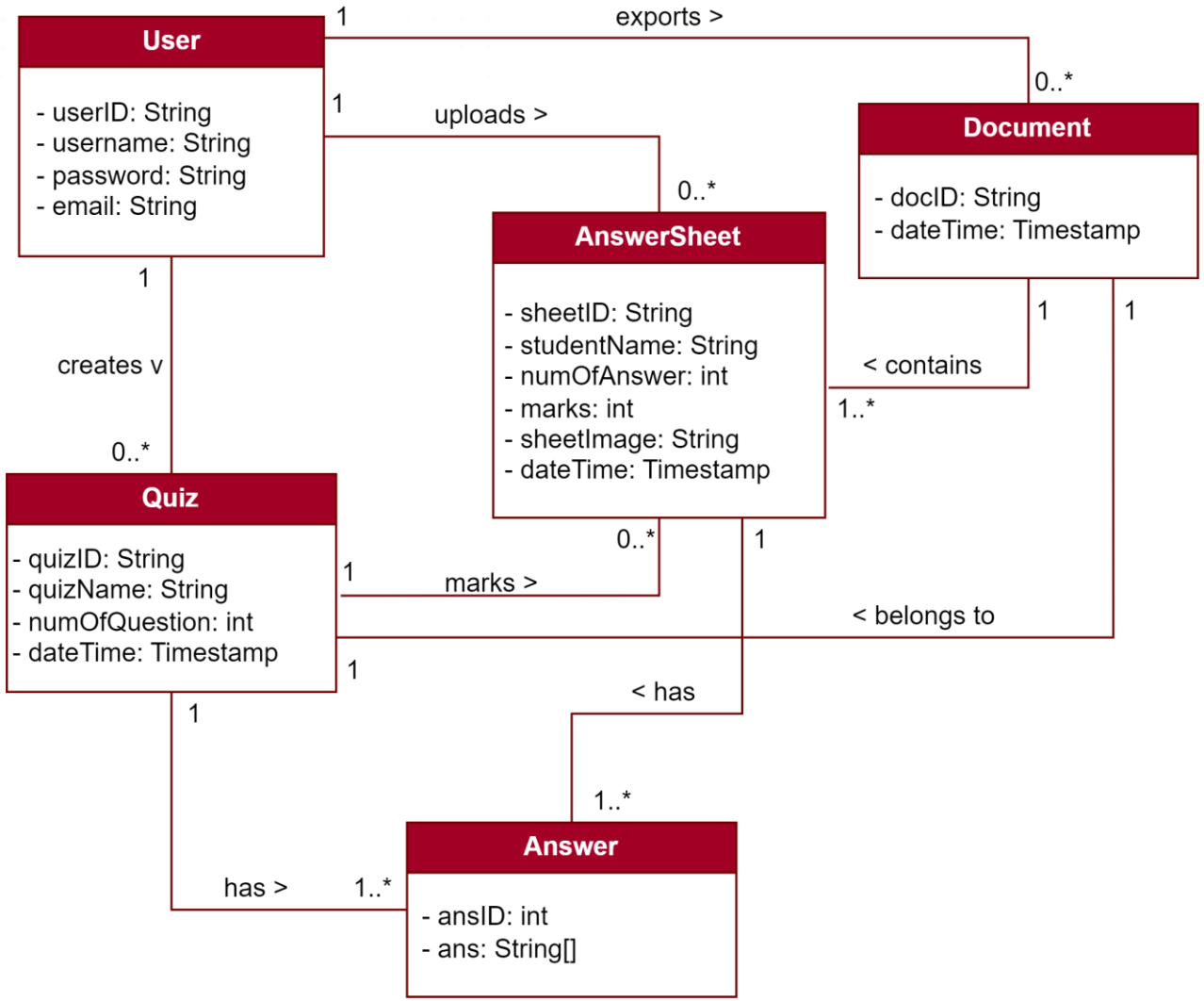


SYSTEM ARCHITECTURE DESIGN

REQUIREMENTS ANALYSIS & DESIGN

DATABASE DESIGN

(ERD)



REQUIREMENTS ANALYSIS & DESIGN

DATABASE DESIGN (JSON DOCUMENT)

User

```
{
    "userID": string,
    "username":
        string,
    "password":
        string,
    "email": string
}
```

Quiz

```
{
    "quizID": string,
    "userID": string,
    "quizName": string,
    "numOfQuestion":
        number,
    "dateTime": timestamp,
    "answers": [
        {
            "ansID": int,
            "ans": [string]
        },
        {
            "ansID": int,
            "ans": [string]
        }
    ]
}
```

AnswerSheet

```
{
    "sheetID": string,
    "userID": string,
    "quizID": string,
    "studentName": string,
    "numOfAnswer":
        number,
    "sheetImage": string,
    "dateTime": timestamp,
    "answers": [
        {
            "ansID": int,
            "ans": [string]
        },
        {
            "ansID": int,
            "ans": [string]
        }
    ]
}
```

Answer

```
{
    "ansID": int,
    "ans": [string]
}
```

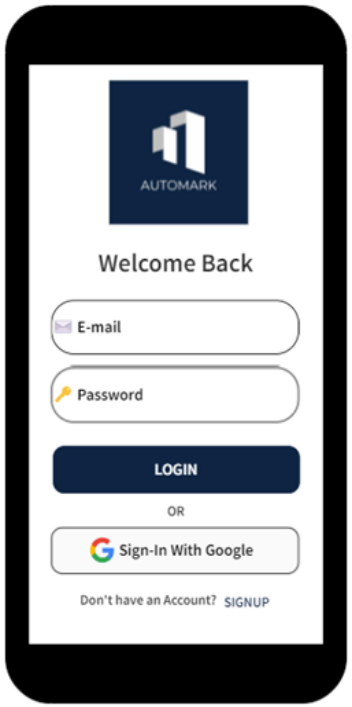
Document

```
{
    "docID": string,
    "dateTime": Timestamp,
    "quizID": string,
    "answerSheetIDs": [string]
}
```

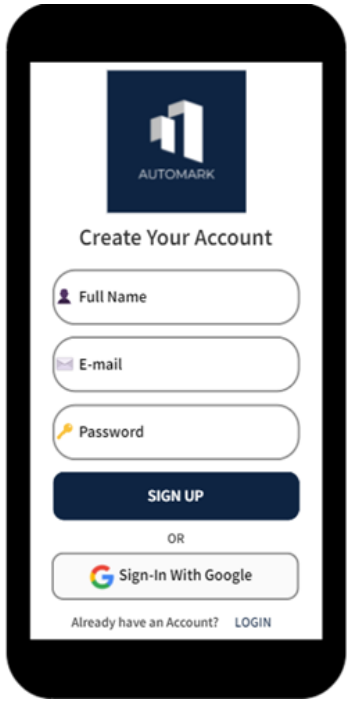
REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (LOGIN AND REGISTER INTERFACE)

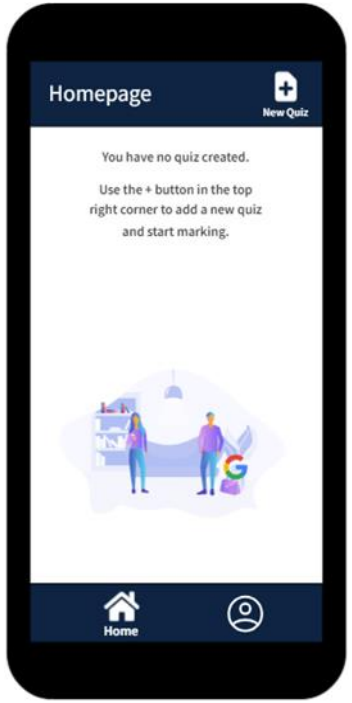
Welcome Page



Login Page



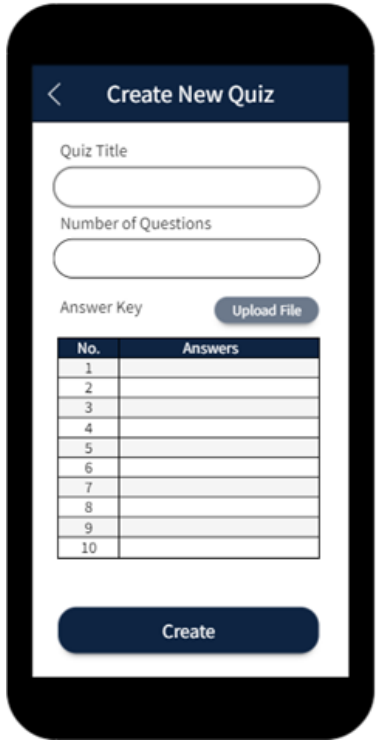
Register Page



Homepage

REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (ADD NEW QUIZ INTERFACE)

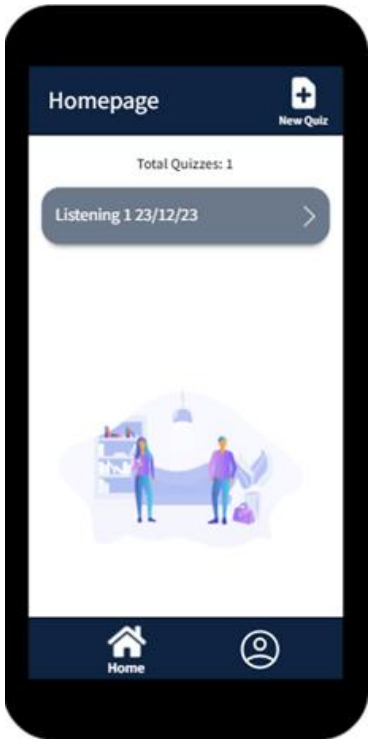


Create Quiz Page

Create Quiz Information Invalid Screen

Create Quiz Page with Complete Information

Create Quiz Information Valid Screen

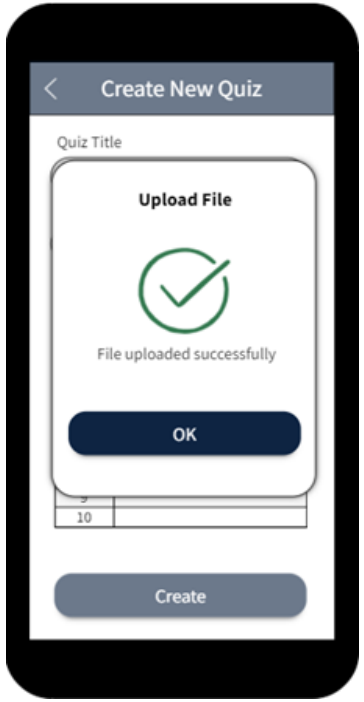


Homepage with Newly Created Quiz

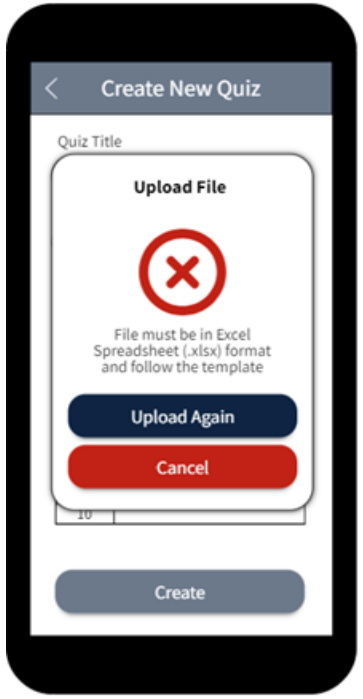
REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (UPLOAD ANSWER SCHEME INTERFACE)

Upload Answer Scheme Screen



Uploaded Answer Scheme Valid Screen

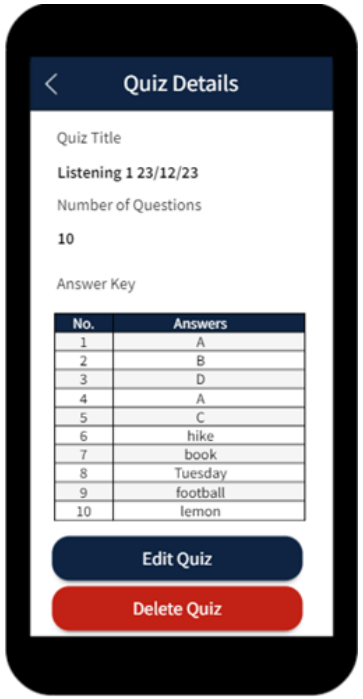


Uploaded Answer Scheme Invalid Screen

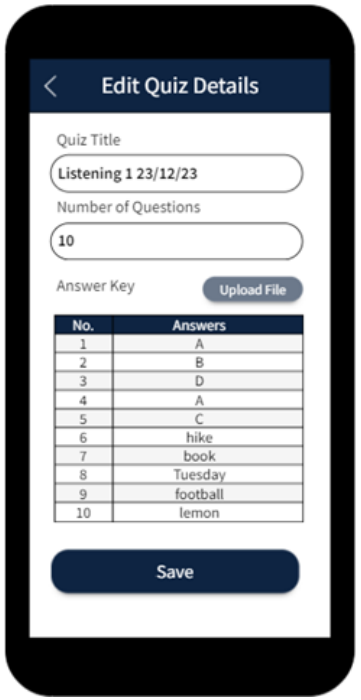
REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (MANAGE QUIZ INTERFACE)

Created Quiz Page



Quiz Details Page



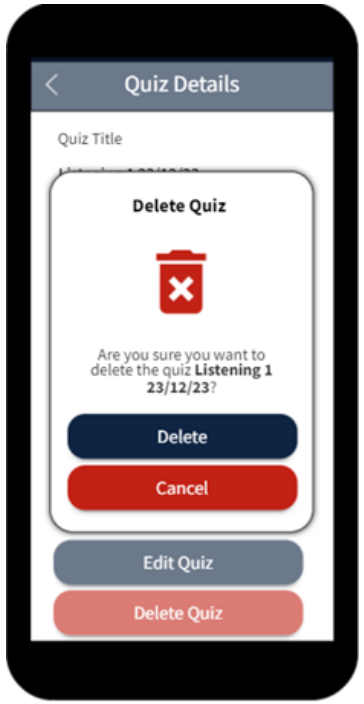
Edit Quiz Details Page

Update Quiz Information Valid Screen

REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (MANAGE QUIZ INTERFACE)

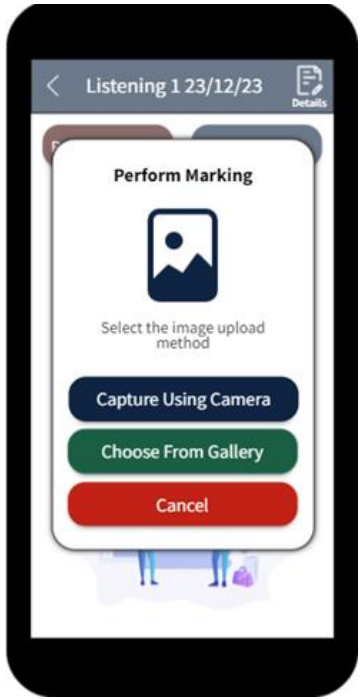
Update Quiz Information Invalid Screen



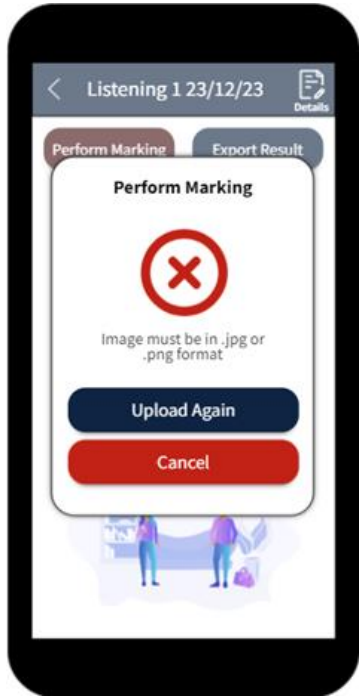
Delete Quiz Screen

REQUIREMENTS ANALYSIS & DESIGN

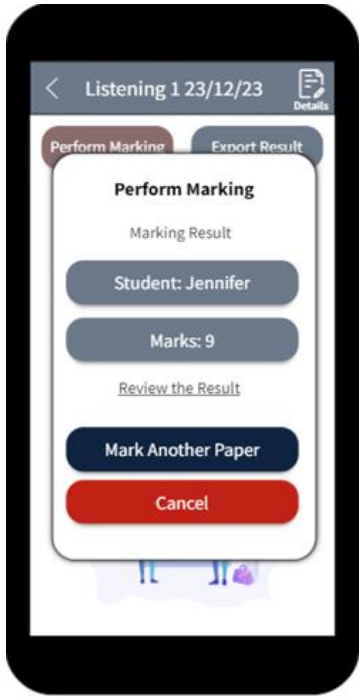
UI DESIGN (PERFORM MARKING INTERFACE)



Perform Marking Screen



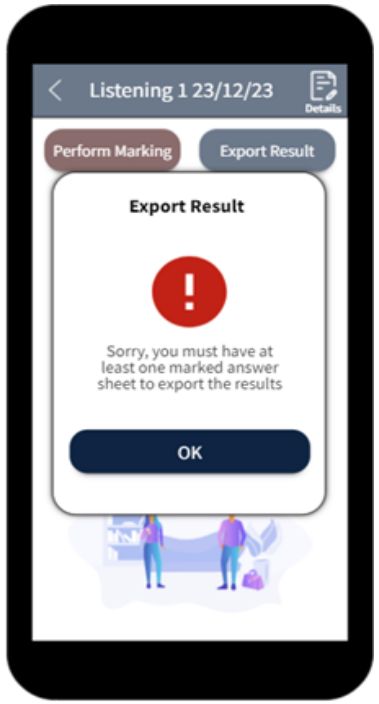
Uploaded Image Invalid Screen



Marking Completed Screen

REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (EXPORT STUDENT RESULT INTERFACE)



Export Student Results Failed Screen

Export Student Results Select Export File Type Screen

REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (MANAGE STUDENT RESULT INTERFACE)

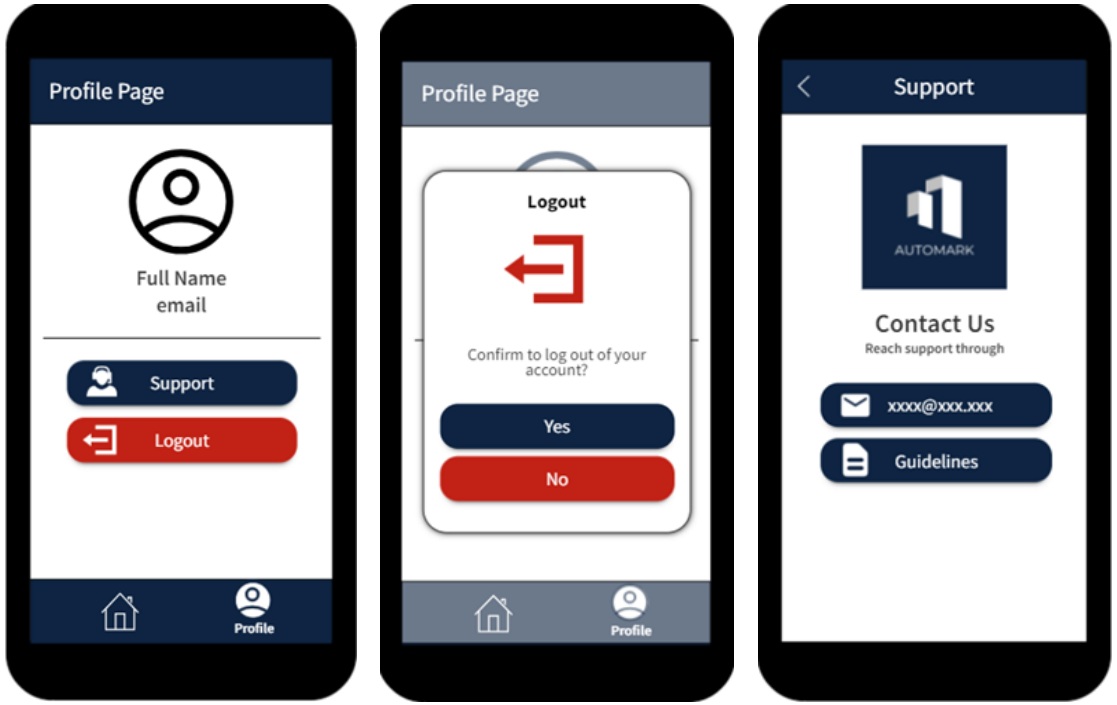
Created Quiz Page with Student Results

Selected Student Result Page

Delete Answer Sheet Screen

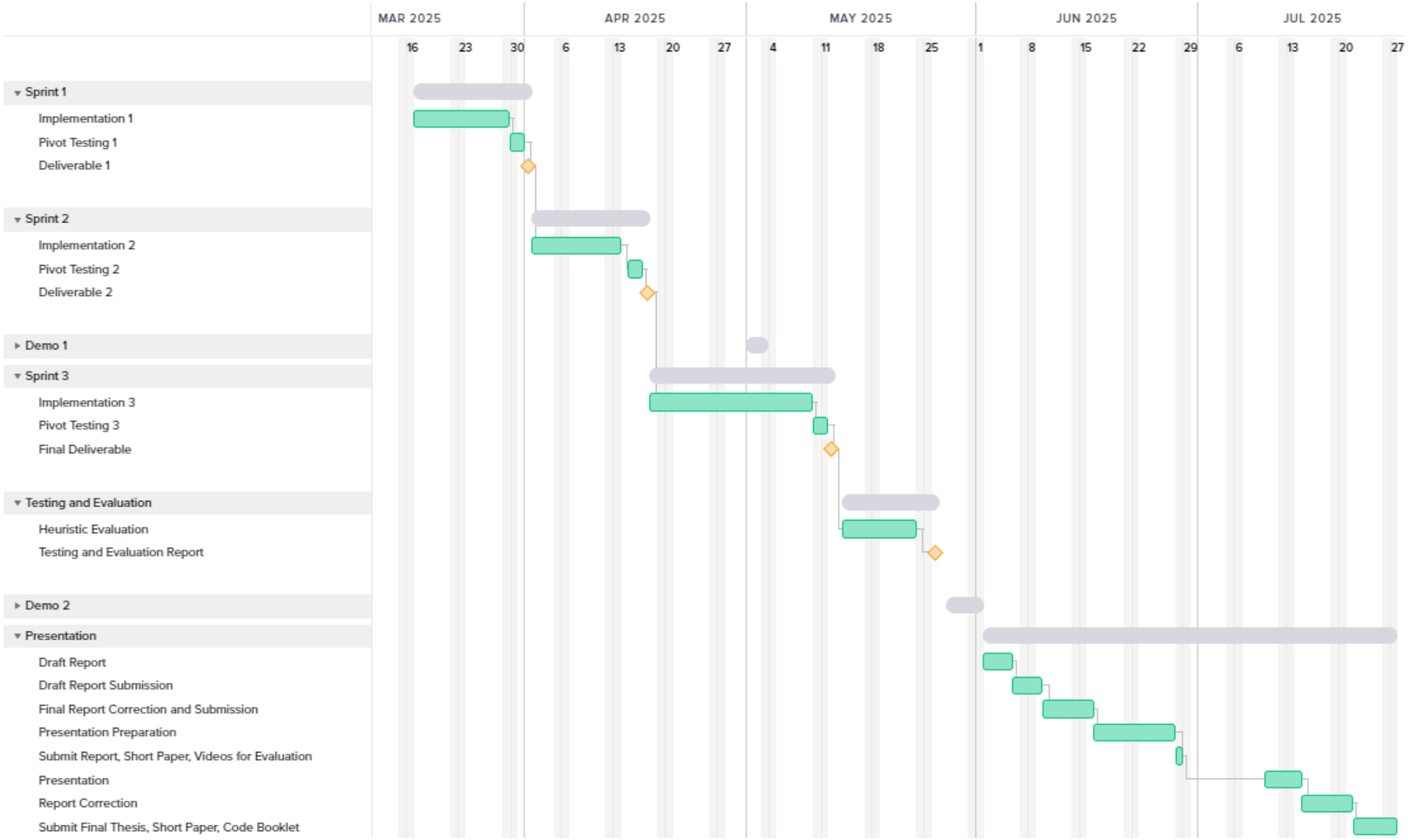
REQUIREMENTS ANALYSIS & DESIGN

UI DESIGN (OTHER INTERFACE)



Profile Page Logout Screen Support Page

PSM2 EXECUTION PLAN



CONCLUSION

“

PSM2 will focus on **implementation and testing** phases, integrating functionalities through iterative sprints. Key activities will include pivot testing after each sprint and heuristic evaluation with experts after final deliverable to evaluate the application’s marking accuracy. Constraints such as time and access to human resources for testing have been acknowledged, influencing project planning.

Objective 1 has been **achieved**, while **objective 2** remains **partially completed** and will **continue into** 'Projek Sarjana Muda’ 2 (**PSM2**). **Objective 3** will also be **extended into PSM2**.

”

THANK YOU

univteknologimalaysia utm.my utmofficial