**A Level computer Science**

Component 3

Physics Homework App

A black and blue logo

Description automatically generated

By: Konstantinos Papadopoulos

For: A. Issa

**Stoke on Trent Sixth Form College**

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# Chapter One: Analysis of the problem

## Introduction

I will be creating a Physics Homework App which will allow teachers to check homework and check students’ performance. It will also allow students to complete their homework. To complete this project, I will be collaborating with the Physics department in my school and some Physics students. They will be stakeholders for this project and they will give me ideas and recommendations of what features to have.

This chapter will outline the problem identification process and will document the process of planning the proposed solution.

## Problem Identification

While studying Physics at A-Level, we used multiple websites to do our homework. This was due to the fact that all of the different websites had their own flaws. The main flaw that I found is that no website that is available to us allows for both calculations and long answers to be entered as answers.

This is an example of a website allowing to answer a calculation question. As you can see in this example, you can only enter a value as an answer and then the website tells you if it is right or wrong. This is a big problem because, if you get the question wrong, you and your teacher will not be able to see where the problem in the calculation is and how to fix it.



As shown in this example, this particular website allows for a long answer to be entered as an answer. However, the limitation of this is that when you are marking your answer, it can only be marked as right or wrong. The solution to this problem is to allow the student to give their answer a mark, by checking their answer against the mark scheme, out of the number of marks that the teacher set. This will allow the student to see what they would score in the real exam.

## 1.3 Why the problem is suited to a Computational Method

Decomposition

A computational method would allow for problem decomposition. This means that every section of the program can be broken down into smaller sub-sections.

Admin view:

* Main window with the main options
* Create student account
* Create assignment
* View assignments
* View submissions
* Account settings

Student view:

* Main window with all assignments
* View past submissions
* Account settings

These smaller sub-sections would allow for a modular program can be used to solve my problem. This means that a computational method is suited for my solution.

Accessibility

A computational solution would improve accessibility to resources by allowing students to complete their work anytime and from anywhere in the world as long as they have an internet connection. This would allow for students that are absent to be able to still complete their work and stay up to date with the content that is taught. Additionally, a computational approach would allow students that have disabilities or bad motor skills to be able to complete their work. This is because, typing requires less physical effort which can strain and be uncomfortable to a person that is suffering from an injury or disability. This means that all students would be able to work and learn no matter what their situation is. As a result, a computational method is suitable to be used.

Usability

Using a computational method to solve my problem would allow for multiple users to access and complete their work simultaneously. Students can complete and mark their assignments while their teacher can view their overall progress. This would be a more efficient and faster approach than the teacher marking each completed assignment and then returning it to the student with feedback. Also, a computational method would allow for a simple user interface that is easy and quick to navigate. Other methods that students use can be very complicated and confusing (for example a file directory or a physical folder with printed worksheets), so a simple UI with the main features in a main window would streamline the user’s experience. Due to this, a computational method can be used to solve the problem.

Storage

When a student is assigned homework, they are given sheets of paper. These pieces of homework can be easily lost. Also, over time, the student would need a lot of physical storage space to store their past and current homework. A computational solution can provide a large amount of storage space that can store the numerous pieces of data. This can be achieved using databases hosted on an online server. This can allow for efficient data organisation, quick and easy deletion and creation of records and an easier analysis of data. Using data analysis, teachers can effectively look for trends in students’ performance and adapt their teaching style accordingly. This means that any important data will not be lost, due to the nature and backups of the database, and it will cut down on the use of paper which will benefit the environment. Hence, a computational method would be suitable and preferred for this solution.

## 1.4 Stakeholders analysis

1.4.1 Stakeholder Introduction

The demographic for my project is for teachers and students in the Physics A-Level. For my stakeholders I picked one Physics teacher and three Physics students. The teacher stakeholder is Mina and my student stakeholders are Ali, Jahin and Violet. I picked a teacher and three students for my stakeholders because I wanted to have many different perspectives where I can take ideas from. I asked each group of stakeholders seven questions. I asked the teacher group the following questions:

1. What resources do you currently use to set physics homework?
2. What are some good features of the current resources that you use?
3. What are some bad features of the current resources that you use?
4. If a new homework website was made, what would you like to see included in it?
5. As a teacher, what are the biggest challenges when setting and marking homework?
6. What would make the website easier to navigate for you?
7. Anything you would like to add that wasn’t included in the questionnaire?

I asked the student group the following questions:

1. What resources do you currently use for your physics homework?
2. What are some good features of the current resources that you use?
3. What are some bad features of the current resources that you use?
4. If a new homework website was made, what would you like to see included in it?
5. What would make the website easier to navigate for you?
6. How can the website motivate you to do your homework?
7. Anything you would like to add that wasn’t included in the questionnaire?

1.4.2 Stakeholder Interviews

My teacher stakeholder interview was with Mina, an A-level Physics teacher. She answered my questions as follows:

What resources do you currently use to set physics homework?

“I use SENECA and Bromcom”

What are some good features of the current resources that you use?

“SENECA provides active learning which can be very beneficial for a student. Bromcom allows for the parents to easily check their kid’s progress, homework and behaviour at school.”

What are some bad features of the current resources that you use?

“Both websites have too many steps when setting a homework”

If a new homework website was made, what would you like to see included in it?

“I’d like to see a feature allowing the teacher to check a student’s progress”

As a teacher, what are the biggest challenges when setting and marking homework?

“Time. Setting a homework can be very time consuming because it involves a lot of steps”

What would make the website easier to navigate for you?

“Limiting the number of clicks required to reach important pages and actions. Also, a clean and uncluttered design”

Anything you would like to add that wasn’t included in the questionnaire?

“No”

My first student stakeholder interview was with Ali. He currently does Computer Science, Maths and Physics at A-Level. His responses were as follows:

What resources do you currently use for your physics homework?

“I currently use Isaac Physics and Carousel Learning for my homework”

What are some good features of the current resources that you use?

“I really like that there is a menu that allows you to review new and completed assignments. I also really like that there are hint options for when I am struggling with a question”

What are some bad features of the current resources that you use?

“One thing I dislike about Carousel Learning is that if I accidently go to the next question, I can’t go back to the previous question. I also really dislike that I can’t do theory questions on Isaac and calculations on Carousel which makes it really inconvenient to do my homework. Another thing I dislike about my current resources is that I don’t get notifications when new homework is set.”

If a new homework website was made, what would you like to see included in it?

“I would really like to see a feature that show how much progress I am making on my homework and how much progress I am making overall.”

What would make the website easier to navigate for you?

“My current resources have a bunch of useless stuff on the screen which makes it hard to navigate so I think a clean UI and design would make the website easier to navigate for me.”

How can the website motivate you to do your homework?

“A point reward system or a praise system when I get a question right and also a class leaderboard to see where I am compared to my classmates”

Anything you would like to add that wasn’t included in the questionnaire?

“No”

My next student stakeholder interview was with Jahin. He is studying Physics, Computer Science and Further Maths. His responses were as follows:

What resources do you currently use for your physics homework?

“I use past papers, Isaac Physics and Carousel Learning”

What are some good features of the current resources that you use?

“They let me work at my own pace, there’s no timers that rush me and stress me out”

What are some bad features of the current resources that you use?

“Some resources don’t have hints on how to solve questions I am stuck on”

If a new homework website was made, what would you like to see included in it?

“An option for hints for when I am stuck on a hard question”

What would make the website easier to navigate for you?

“A simple UI with no over-the-top styling”

How can the website motivate you to do your homework?

“Maybe a leaderboard comparing you against classmates”

Anything you would like to add that wasn’t included in the questionnaire?

“I would like to see that the app has a low bandwidth usage because the Wi-Fi in some places is really bad”

My final student interview was with Violet. She is studying Physics, Maths and Geography. Her interview went as follows:

What resources do you currently use for your physics homework?

“I use Physics and Maths tutor, questions from the textbooks and slides from the teachers”

What are some good features of the current resources that you use?

“They are easily accessible and have a wide range of topics”

What are some bad features of the current resources that you use?

“They have bad layouts which makes it hard to find the resources I need sometimes”

If a new homework website was made, what would you like to see included in it?

“I would like to see a main screen with all important features included in that screen”

What would make the website easier to navigate for you?

“A better layout with no clutter”

How can the website motivate you to do your homework?

“Some kind of praise system would be great”

Anything you would like to add that wasn’t included in the questionnaire?

“No”

1.4.3 Stakeholder Conclusion

From the interviews I conducted with my stakeholders, I can conclude the following:

What are some good features of the current resources that you use?

My stakeholders liked that the current resources let them work at their own pace. As a result, I will not be adding any timers to the assignments as this could stress out a student. My stakeholders also liked that the resources that they use are easily accessible. Due to this, I will make my solution into an executable file that will require minimal computer resources.

What are some bad features of the current resources that you use?

My stakeholders disliked that they have to use two different applications for their homework assignments. Due to this, I will allow for both calculation and written questions to be set and answered. My stakeholders also disliked that there are no hint options on their homework. This is a good feature to have, however, I will not be incorporating this feature into my solution. I chose to remove this feature because, if the student is stuck on a question, it would be more helpful to their education for them to do the research/revision by themselves instead of getting multiple hints that will get them to the answer. Also, if this feature is removed, the homework setting process would be much quicker and easier (this was the main problem that my teacher stakeholder identified).

If a new homework website was made, what would you like to see included in it?

My teacher stakeholder outlined that they would like to see a feature that would allow for them to check the students’ progress. My student stakeholders also identified this as a feature that they would like to see included. As a result, I have decided to include this feature to my solution as it was the main feature that my stakeholders wanted to see and I believe that checking your progress is vital to improving.

What would make the website easier to navigate for you?

All my stakeholders identified that they want a clean and uncluttered user interface that is easy to use. I will incorporate this into my solution by removing unnecessary buttons and having a main window with all of the important actions.

## 1.5 Research of solutions for similar problems

1.5.1 S**imilar existing solutions**

Seneca Learning

How does it work?

A screenshot of a video game

Description automatically generatedOne similar solution to my problem that I found is a website called Seneca Learning. This website has pre-made modules for many subjects and exam boards. The layout for homework does not allow students to do calculations. When completing a homework on Seneca Learning, the answer is given to you as an explanation and you are then given a question to answer (usually a complete the sentence question). This is website would be really good for students at the GCSE level but for A-Level students it would not be useful.

What components and features can be borrowed?

Seneca learning has many features that are very useful for a student to have. It has a class system that allows for teachers to create their own classes and then set homework for all the students in those classes. This feature will be borrowed because it will make it easy for teachers to set homework for their classes and it would allow teachers to group their students in their respective classes.

One feature that I find to be a bad feature, is the ability for a student to create their own account. I think this is bad because, when students are signing up, they can choose if they are a student, teacher or parent. Having access to this feature means that a person with malicious intentions can create multiple teacher accounts and cause a big problem in a school system. Due to this, for my solution, I will only allow teacher to create student accounts and then having the system send the student an email with their details.

Carousel Learning

How does it work?

Another similar solution I found to my problem is Carousel Learning. In this solution, teachers set homework (the teachers enter the questions and answers as there are no premade modules) and then students answer and mark their answers. When marking, the students can only mark their answers as correct or incorrect.

This solution is a website. Students access the website via a link that is sent to them by their teacher. This link takes students straight to the assignment (there is no student area where they can view progress/upcoming assignments). When the students are directed to the assignment, they log in using their first and last name (their accounts are created by their teacher and no password is required).

What components and features can be borrowed?

From this solution, I can only borrow the feature where the student marks their own questions. However, I will allow the students to assign themselves a mark instead of marking their answer as correct or incorrect. I am doing this as it is more beneficial for the student to see what mark they would have scored in the exam rather than seeing if their answer is correct.

I believe that the login system that the website currently uses is a big security issue as the users don’t have passwords. This would allow students to log in to other students’ accounts as they only need their name. As a result, I will have a main login window where the students/teachers need to enter their email address and password.

## 1.6 Hardware and software requirements

1.6.1 User requirements

My solution will require a computer with the standard I/O devices (keyboard, mouse and monitor) so the user can interact with the application. My solution is a python based application. However, the user will not need to have python installed as the application will be compiled into an executable file. An internet connection will also be required so the application can access the database. This will be needed so the user can log in and see their assignments. The following requirements are the minimum requirements needed for the application to run. Most computers and laptops will already meet the requirements as python executable files are not very demanding when it comes to hardware and software requirements.

Hardware:  
- Processor: Any multicore processor. This will allow for faster computations and more efficient multitasking.

- RAM: At least 1GB as the application has a GUI and it will run slow with less RAM. (this amount is not required but it is recommended)

- Storage: At least 100MB to store the executable file and any temporary files.

- I/O devices: Keyboard, mouse and monitor. This will allow the user to use and interact with the application.

Software :

- Operating System: Windows 7 or above, macOS or a Linux based system. These are the current operating systems supported by python.

- Other software will not be needed as all the libraries used will be already bundled with the executable file.

1.6.2 Solution requirements

My solution will require an online PostgreSQL database. This is because it needs to store all the login and assignment information. A local database will not be suitable for my solution as there will be multiple teachers and students that need to access the database from different devices at the same time. An online database would ensure maximum data security as the data can be backed up and encrypted. Also, if an online database is used, the overall memory space needed for my solution would be reduced as the user wouldn’t need to store the database in their device. As a result, my solution will require a webserver to host the database.

## 1.7 The requirements of the solution

Using my stakeholder interviews and research into similar solutions, I decided that the following features would be included in my solution.

|  |  |  |
| --- | --- | --- |
| Feature | Description | Justification |
| Login System | Users should be able to login to the system with their credentials | This would allow for all users to access their personal area with their data. This would also allow for different people with different permissions (admin/student) to access the correct area. |
| Two-factor authentication system | Users should receive an email with a one time password and enter it correctly to log in. | This adds an extra level of security. A person with malicious intentions would need to also have access to the user’s email account. |
| Ability to change email and password of the user’s account | Users should be able to modify their account email and password | This would allow users to change their emails just in case they have lost access to their email account. Users should be able to change their password increases security as they can personalise their password. Also, giving users this ability means that they won’t have to contact admins to change their password and compromise security. |
| Ability to create assignments (Teachers only) | A teacher should be able to create an assignment and add questions to the assignment | Creating an assignment is a core part of a homework program. Teachers should be the only users that can set a homework because students with malicious intent could overload the system. |
| Ability to create and delete classes (Teachers only) | A teacher should be able to create and delete classes | A teacher should be able to group students in their respective classes. This would allow for assignment setting to be easier as the teacher won’t have to add every student to the assignment individually. |
| Ability to view active/past assignments and submissions (Teachers only) | A teacher should be able to view the current and past assignments. They should also be able to view the submissions to those assignments. | This would allow for teachers to monitor student progress and performance. |
| Ability to create user accounts (Teachers only) | A teacher/admin should be able to create accounts for students | Only teachers and admins should be able to do this. This is because, if a student had malicious intent, they could create many accounts and flood the databases and system with fake accounts |
| Ability to see active assignments (Students only) | A student should be able to see all their active assignments on the main screen | A student should be able to view their assignments on the main screen. This will allow the assignments to be accessible and easy to find at any time. |
| Ability to view past completed assignments (Students only) | A student should be able to see their past assignments and their scores on those assignments | Allowing a student to look at past assignments would allow the student to look at their past performance and progress. This would allow the student to see what topics they didn’t do well in and revise those topics. |
| Ability to complete assignments (Students only) | A student should be able to answer all the questions in an assignment and mark their answers | A student should be able to mark their own answers. This is because it would help them see what topics they perform bad in and it would allow them to see what they would have scored in the actual exam. |

## 1.8 Limitations of the solution

One of the main limitations of my solution is that it will only be available on a computer or laptop because these platforms offer better specifications than phones (such as faster processors and more storage space. This would lead to a smoother performance and overall better experience while using the application. Therefore, while the application runs better on laptops and computers, it will be inaccessible to users that do not own such a device and to users that prefer to work on their mobile devices. This could be improved if the solution was hosted on a website instead of an application.

Another limitation of the solution is that it is limited only to the Physics subject as it is designed so students can answer long answers and calculations. The current design could also be used for other subjects like Biology and Computer science but it could only be used for some types of questions. The solution could be altered to fit the rest of the A-Level subjects but it may not meet the full list of requirements for the needs of the Physics students, my target user group.

The last main limitation of my solution requires a constant, un-interrupted connection to the PostgreSQL database hosted on the webserver. Because of this, any outage in the host would mean that my solution would not function properly and most of the main features would be unusable. A local database could be used, but this would lead to several security issues and unauthorised access to the database. Therefore, an online database host is the only viable option for my solution.

## 1.9 Success Criteria

1.9.1 Universal success criteria

|  |  |  |  |
| --- | --- | --- | --- |
| Requirement | Description | Justification | Evidence |
| Login System | A system that allows a user to enter their credentials and log in to the system | A login system would allow users to enter their respective area with their work and correct permissions (teacher/admin permissions or student permissions) | Screenshots and GIFs will be used as evidence to show the functionality of the login system |
| Two-Factor Authentication System | A 2FA system where the user receives a code in their email | A 2FA system adds a second layer of security. An attacker would need access to the user’s email account to access this 2FA code | Screenshots and GIFs will be used as evidence to show the functionality of the 2FA system |
| A user can change their email or password | A user should be able to modify their account email and password | A user can forget their password or lose access to their email account. Having this feature would allow for users to never lose access to their account | Screenshots and GIFs will be used as evidence to show the functionality of the change email/password system |

1.9.2 Teacher/Admin success criteria

|  |  |  |  |
| --- | --- | --- | --- |
| Requirement | Description | Justification | Evidence |
| A teacher/admin can create an assignment | A teacher/admin should be able to create an assignment and set it to a class | Setting an assignment is the main feature of this application. Only teachers will be able to set assignments so students with malicious intents don’t overload the database | Screenshots and GIFs will be used as evidence to show that the assignment setting system functions correctly |
| A teacher/admin can create and delete classes | A teacher/admin should be able to group students together into their respective classes | This will make the assignment setting easier as students will be grouped in their respective classes | Screenshots and GIFs will be used as evidence to show the functionality of the class system |
| Ability to view past and current assignments | A teacher/admin should be able to view a list of all past and currently active assignments | This will allow the teacher to manage how much homework they set and what topics have already been assigned | Screenshots and GIFs will be used as evidence to show the functionality of the assignment viewing system |
| Ability to view student submissions to set assignments | A teacher/admin should be able to view a list of student submissions and achieved mark and date submitted | This will allow the teacher to track student progress and performance | Screenshots and GIFs will be used as evidence to show the functionality of the submission viewing system |
| Ability to create student accounts | A teacher/admin should be able to create accounts for students | Only teachers/admins should have the permission to create accounts. A student with malicious intent could create multiple accounts and overload the system if this permission was given to all users | Screenshots and GIFs will be used as evidence to show the functionality of the account creation system |

1.9.3 Student success criteria

|  |  |  |  |
| --- | --- | --- | --- |
| Requirement | Description | Justification | Evidence |
| Ability to see all active assignments | A student should see all their active and uncompleted assignments on the main screen | The assignments of a student should be easily accessible | Screenshots and GIFs will be used as evidence to show the functionality of the assignment system |
| Ability to view past and completed assignments | A student should be able to view a list of their past, completed assignments and view the mark they achieved | A student should be able to view their performance and track their progress. This would allow the student to revisit topics they underperformed on | Screenshots and GIFs will be used as evidence to show the functionality of the past assignment list system |
| Ability to answer and mark assignments | A student should be able to answer, complete and mark an assignment | A student should be able to mark their own answers. This will allow them to see what they would have actually scored in the exam. | Screenshots and GIFs will be used as evidence to show the functionality of the assignment system |

# Chapter Two: Design

## 2.1 Introduction

In this section I will outline the design process of my solution. I will also show the decomposition of my solution into smaller and more manageable sub-sections.

## 2.2 Decomposition of the problem

Since a project with many features can be very complex, my solution will be broken down into more manageable sub-sections.

For the design of my solution, I have split my program into three smaller sub-sections. The login system, the admin view and the student view. The login system, will allow users to enter their credentials and log in to their respective area. This enables users to access their personal data and assignments. The second section is the admin view. This section provides the ability to create student accounts, create assignments and classes, and view student submissions and assignments. The final section, the student view, will allow students to complete and mark their assignments, and view their past submissions. Both the admin view and student view will have access to the settings area.

2.2.1 Decomposition Diagram

A screenshot of a computer screen

AI-generated content may be incorrect.The following diagram outlines the proposed decomposition design of the solution.

(Figure 1 in evidence)

2.2.2 Flow Charts / Data Flow Diagram

The following diagrams outline where and how the data flows through the different parts of the program.

A screenshot of a computer screen

AI-generated content may be incorrect.

A black background with many different colored rectangular objects

AI-generated content may be incorrect.Data flow diagram for the class system (Figure 3 in evidence)

Data flow diagram for the assignment system (Figure 4 in evidence)

A screenshot of a computer screen

AI-generated content may be incorrect.

Data flow diagram for the account system (Figure 5 in evidence)

2.2.3 Input Process Output Charts

Login system:

|  |  |  |
| --- | --- | --- |
| Input | Process | Output |
| Email and password | Hashes the password, then checks against the database to see if the credentials are valid/invalid | Error message or two-factor authentication window |
| One-time password | Verifies the one-time password and returns True or False | Error message or creation of amin/student window |

Registering student account:

|  |  |  |
| --- | --- | --- |
| Input | Process | Output |
| Student information (name, email, password) | Checks if both passwords match, validates the name, email and password, and checks if the email is already in the database. Then writes data to student accounts table (if all tests pass) | Error or success message |

Creating assignments:

|  |  |  |
| --- | --- | --- |
| Input | Process | Output |
| Assignment information (Title, class assigned to and due date) | Validates data entered. If all data is valid, it creates a table with a randomly generated name and inserts the assignment information to the assignments table | Error message or creation of the add questions window |
| Question information (Question, answer, mark) | Validates data. If valid add question information to the table for that assignment. | Completion message or next question window (depending on if the user clicks complete or next) |

Creating classes:

|  |  |  |
| --- | --- | --- |
| Input | Process | Output |
| Class information (class name and students) | Validates if data is empty. If validation succeeds, creates a table for the class with the selected students and adds the class information (class name and id) to the classes table | Error or success message |

Deleting classes:

|  |  |  |
| --- | --- | --- |
| Input | Process | Output |
| Class name | Validates if a class name has been picked. If so, class table is deleted and record is removed from the classes table | Error or success message |

Settings system:

|  |  |  |
| --- | --- | --- |
| Input | Process | Output |
| Email | Checks if emails entered match, validates the email and checks if it already exists. If all tests pass, email is updated in the database | Error or success message |
| Password | Checks if passwords entered match, validates the password If all tests pass, the password is hashed and updated in the database | Error or success message |

Answering assignments:

|  |  |  |
| --- | --- | --- |
| Input | Process | Output |
| Answer | Checks if answer is empty. If not, a Json file is created and stores the answers | Error message or next question (or marking window) |
| Mark | Checks if it is an integer. If it is, checks if it is the last question. If it is, the Json file is deleted, marks are totalled up and added to the submissions table. | Error message or next question marking window or marking over message |

## 2.3 How All Solution Parts are Linked

2.3.1 State Diagrams of the different sections

Login system:

A black and white rectangular object with text

AI-generated content may be incorrect.

(Figure 6 in evidence)

Admin view:

A screenshot of a computer screen

AI-generated content may be incorrect.(Figure 7 in evidence)

Student view:

A screenshot of a computer screen

AI-generated content may be incorrect.

(Figure 8 in evidence)

2.3.2 How different functions /classes are connected

## 2.4 Database Design

2.4.1 Data dictionaries

Table name: admin\_acc

This table will store all the admin and teacher accounts. More rows can’t be added to this table unless the database is accessed directly in the database website.

It will store the following information:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Data Type | Length | Rules | Comments | Example |
| id | Integer | One digit and above | N/A | Primary key. Generated by the database | 13 |
| email | Varchar | N/A | Must be in the form: example@domain.com | Stores the user’s email | “JohnSmith@hotmail.com” |
| password | Varchar | N/A | N/A | Stores the user’s hashed password | 1d460455f292dc60ed53ad  bea5365bfa27262c25e724  a6eecec799f203a69d7a |
| name | Varchar | More than 5 characters | Must have a space in the middle | Stores the user’s name | “John Smith” |

Table name: main\_acc

This table stores all the student accounts. This table can be changed by any admin or teacher when creating an account.

It stores the following information:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Data Type | Length | Rules | Comments | Example |
| Id | Integer | One digit and above | N/A | Primary key. Generated by the database. | 32 |
| name | Varchar | More than 5 characters | Must have a space in the middle | Stores the user’s name | “Rachel Smith” |
| password | Varchar | N/A | N/A | Stores the user’s hashed password | 1d460455f292dc60ed5  3adbea5365bfa27262c  25e724a6eecec799f20  3a69d7a |
| email | Varchar | N/A | Must be in the form: [example@domain.com](mailto:example@domain.com) | Stores the user’s email | “RachelSmith@gmail.com” |
| teacher\_id | Integer | One digit or above | N/A | Foreign key. Links with the id column in the admin\_acc table | 21 |

Table name: stud\_classes

This table stores all the class names and which teacher own them. This table is updated when a class is created or deleted.

It stores this information:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Data Type | Length | Rules | Comments | Example |
| Id | Integer | One digit and above | N/A | Primary key. Generated by the database. | 54 |
| class\_names | Varchar | More than one character | N/A | Stores the name of the class | “Physics Class 7E” |
| teacher\_id | Integer | One digit or above | N/A | Foreign key. Links with the id column in the admin\_acc table | 12 |

Table name: assignments

This table stores the information of every assignment. This table is needed to allow for many-to-many table relationships to happen. It also makes looking for an assignment easier.

It follows this structure:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Data Type | Length | Rules | Comments | Example |
| assign\_id | Integer | One digit and above | N/A | Primary key. Generated automatically by the database | 31 |
| title | Varchar | More than 2 characters | N/A | Stores the title of the assignment | “The Solar System” |
| class\_id | Integer | One digit and above | N/A | Foreign key. Links to the stud\_classes table. Stores the class which the assignment is assigned to . | 54 |
| due\_date | Datetime | N/A | Must be in the format yyyy-mm-dd | Stores the due date of the assignment. Chosen by the teacher | 2024-09-14 |
| teacher\_id | Varchar | One digit and above | N/A | Foreign key. Links to the admin\_acc table. Stores which teacher set the assignment | 13 |
| title\_id | Varchar | N/A | Must be in the format a12345678 | Created automatically when creating an assignment. Id is unique to each assignment | "a99217410" |

Table name: submissions

This table is used to store the student’s homework submissions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Data Type | Length | Rules | Comments | Example |
| subm\_id | Integer | One digit and above | N/A | Primary key. Generated automatically when the assignment is submitted | 14 |
| assignment\_id | Integer | One digit and above | N/A | Foreign key. Links to the assignments table. | 54 |
| student\_id | Integer | One digit and above | N/A | Foreign key. Links to the main\_acc table. Stores which student submitted the assignment | 21 |
| submission\_date | Datetime | N/A | Must be in the format yyyy-mm-dd | Stores when the assignment was submitted. | 2025-12-13 |
| mark | Integer | One digit and above | N/A | Stores the mark that the student achieved | 13 |

When a teacher creates an assignment, a table is created into the database that stores all the questions and answers. The structure of that table is as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Data Type | Length | Rules | Comments | Example |
| questionnum | Integer | One digit and above | N/A | Primary key. Generated in a sequential order. | 3 |
| assignment\_id | Integer | One digit and above | N/A | Foreign key. Links with the assignments table. | 4 |
| question | Varchar | More than 5 characters | N/A | Stores the question | “What is the mass of the Sun?” |
| answer | Varchar | More than one character | N/A | Stores the answer | “17 kilograms” |
| marks | Integer | One digit and above | N/A | Stores the marks the question is worth | 2 |
| question\_type | Varchar | N/A | The teacher can select one of two options when creating the assignment (Standard answer/Calculation) | Stores the type of question. The UI when answering the question changes depending on the type. | “Standard answer” |

When a class is created, a table is made that stores all the students that are in that class. It follows this structure:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Data Type | Length | Rules | Comments | Example |
| student\_id | Integer | One digit and above | N/A | Primary key. Generated by the database when the class is created | 23 |
| student\_name | Varchar | More than 5 characters | Must have at least one space | Stores the student’s name | “Laurence Stone” |

A computer screen shot of a diagram

AI-generated content may be incorrect.2.4.2 Entity Relationship Diagram

(Figure 2 in evidence)

2.4.3 SQL Pseudocode

The following Pseudocode defines creation of the tables I need in the database.

CREATE TABLE IF NOT EXISTS admin\_acc(

Id INT AUTO INCREMENT NOT NULL,

Email varchar(255) NOT NULL,

Password varchar(255) NOT NULL,

Name varchar(100) NOT NULL,

PRIMARY KEY(Id)

);

CREATE TABLE IF NOT EXISTS main\_acc(

Id INT AUTO INCREMENT NOT NULL,

Name varchar(100) NOT NULL,

Password varchar(255) NOT NULL,

Email varchar(255) NOT NULL,

Teacher\_id INT NOT NULL,

PRIMARY KEY(Id),

FOREIGN KEY(Teacher\_id) REFERENCES admin\_acc(Id)

);

CREATE TABLE IF NOT EXISTS stud\_classes(

Id INT AUTO INCREMENT NOT NULL,

Class\_names varchar(255) NOT NULL,

Teacher\_id INT NOT NULL,

PRIMARY KEY(Id),

FOREIGN KEY(Teacher\_id) REFERENCES admin\_acc(Id)

);

CREATE TABLE IF NOT EXISTS assignments(

Assign\_id INT AUTO INCREMENT NOT NULL,

Title varchar(255) NOT NULL,

Class\_id INT NOT NULL,

Due\_date datetime NOT NULL,

Teacher\_id INT NOT NULL,

Title\_id varchar(9) NOT NULL,

PRIMARY KEY(Assign\_id),

FOREIGN KEY(Class\_id) REFERENCES stud\_classes(Id)

FOREIGN KEY(Teacher\_id) REFERENCES admin\_acc(Id)

);

CREATE TABLE IF NOT EXISTS submissions(

Subm\_id INT AUTO INCREMENT NOT NULL,

Assignment\_id INT NOT NULL,

Student\_id INT NOT NULL,

Submission\_date datetime NOT NULL,

Mark INT NOT NULL,

PRIMARY KEY(Subm\_id),

FOREIGN KEY(Assignment\_id) REFERENCES assignments(Assign\_id),

FOREIGN KEY(Student\_id) REFERENCES main\_acc(Id)

);

The following table is created by the program when an assignment is created. It is assigned a randomly generated name following the form ‘a12345678’. This name is stored in the assignments table under the column Title\_id. Due to this, the program can automatically detect if the same randomly generated string is already in use which makes the use of a “IF NOT EXISTS” statement unnecessary. The name used in the SQL query is an example of what the name of the table would look like.

CREATE TABLE a12456381(

Questionnum INT AUTO INCREMENT NOT NULL,

Assignment\_id INT NOT NULL,

Question varchar(500) NOT NULL,

Answer varchar(500) NOT NULL,

Marks INT NOT NULL,

Question\_type varchar(30) NOT NULL,

PRIMARY KEY(Questionnum),

FOREIGN KEY(Assignment\_id) REFERENCES assignments(Id)

);

The following table is created when a teacher creates a class. It stores which students are in that class. This table is used to avoid a many-to-many relationship between main\_acc and assignments. Each table name will be different and set by the teacher. ‘Physics\_Y2’ will be used as an example.

CREATE TABLE IF NOT EXISTS Physics\_Y2(

Student\_id INT NOT NULL,

Student\_name NOT NULL,

PRIMARY KEY(Student\_id),

FOREIGN KEY(Student\_id\_) REFERENCES main\_acc(Id)

);

2.4.4 Test plan for database

|  |  |  |  |
| --- | --- | --- | --- |
| Test No. | Test | Test data | Justification |
| 1.0 | Program can connect to the database | Correct database URL | The program needs to be able to make a connection to the database so it can read and write data. |
| 1.1 | There is an error pop-up when connection is not achieved | Incorrect database URL | It is important for an error to be displayed if there is no connection to the database. This is because, if the database host is experiencing issues or there isn’t an internet connection, the program can stop attempting to make a connection. |
| 1.2 | Data can be read from the database | Read a student’s name | It is important for the program to be able to read data accurately from the database. |
| 1.3 | Data can be inserted into a table | Creating a new student | It is important for the program to be able to write to the database. This will allow for new users to be created |
| 1.4 | Data can be deleted from a table | Remove a student | It is important for the program to delete records from tables. This will allow for the deletion of out-of-date data. |
| 1.5 | Tables can be created | Create a class | It is important for the program to be able to create new tables in the database. This will allow for new classes and assignments to be created |
| 1.6 | Tables can be deleted | Delete a class | It is important for the program to be able to delete tables from the database. This will allow old classes to be deleted from the records. |

## 2.5 Design of other Parts of the Solution

2.5.1 Login System

### A screenshot of a computer screen AI-generated content may be incorrect.

(Figure 9 in evidence)

2.5.1.1 User Interface

For this project, I am using the Tkinter library to create the user interface. I chose Tkinter due to the fact that it is a built-in library so it won’t use any storage space on the user’s computer. Also, the Tkinter library works across every operating system. This would lead to an easier development process and improved accessibility to students with different devices. Therefore, Tkinter will provide a user-friendly interface with minimal compatibility issues.

I designed the following diagrams of how I would like the user interface to look like.



(Figure 10 and Figure 11 in evidence)

I decided on a light grey background with black text (this will stay the same throughout the project) because both colours contrast each other. Also, this background colour, doesn’t strain the eyes as much as a pure white background would. This means that the user interface will have a good readability. Therefore, people that have trouble reading could use the application thus improving the accessibility of this application.

The exit button, once pressed, closes the login window. The eye symbol next to the password text box toggles the visibility of the password. When entering the password, it is automatically shown as asterisks. This is done to prevent shouldering and increase the security of the system. The log in button, once clicked, gets the information entered in the text boxes, hashes the password and checks the credentials against the database. If the credentials are correct, the two-factor authentication window is created and overlayed over the login window. If the credentials entered do not match a record in the database, an error message window is created and overlayed over the login window.

On the 2FA window, the resend code button resends the email with the one-time password to the user. The verify button checks if the OTP entered is correct. If the OTP entered is incorrect, an error message window is overlayed over the 2FA window. If the OTP is correct, the login and 2FA windows are destroyed and the admin/student view is opened.

2.5.1.2 Validation Rules

|  |  |  |
| --- | --- | --- |
| Data | Validation rule | Justification |
| Email | Must be in the format “example@domain.com” | This is the accepted and recognised email format |
| Password | Must be between 8 and 20 | A password that is 8 characters and above ensures an added level of complexity and security. Restricting the maximum characters to 20, limits the storage space used in the database. |
| Password | Must have at least 1 uppercase letter, 1 lowercase letter, 1 number and 1 of the following symbols !@\_& | This adds a level of security that would deter brute force attacks. This means no unauthorised person can enter the system |

2.5.1.3 Key Variables/Data Structures/Classes

|  |  |  |
| --- | --- | --- |
| Item | Data type | Description |
| Email | Varchar | This stores the user’s email. This is the main identifier when logging in. |
| Password | Varchar | This stores the user’s password. It is hashed before it is checked against the database. |
| OTP | Varchar | This stores the entered one-time password. It is checked and verified against the generated OTP. Without a correct OTP, the user will not be able to log in |

2.5.1.4 Algorithms and Pseudocode

Password validation pseudocode:

Function validatePassword(password):

If password matches the regular expression pattern '[A-Za-z0-9!@\_&]{8,20}':

If password does not contain any uppercase letter:

Return False

Else If password does not contain any lowercase letter:

Return False

Else If password does not contain any digit:

Return False

Else If password does not contain any special character from '!@\_&':

Return False

Else:

Return True

Else:

Return False

Endif

End function

Email validation pseudocode:

Function validEmail(email):

Define regex as the regular expression pattern for a valid email:

'([A-Za-z0-9]+[.-\_])\*[A-Za-z0-9]+@[A-Za-z0-9]+(\.[A-Z|a-z]{2,})+'

If email matches the regex pattern:

Return True

Else:

Return False

Endif

End function

2.5.1.5 Test Plan

The following is the test plan that I will adhere to. This test plan will ensure that all combinations of data entry are tested.

Login window:

|  |  |  |  |
| --- | --- | --- | --- |
| Test No. | Test | Test Data | Justification |
| 1.1 | Empty fields produce an error message | Email: NULL  Password: NULL | Invalid data |
| 1.2 | Empty password field produces an error message | Email: testemail@gmail.com  Password: NULL | Invalid data |
| 1.3 | Empty email field produces an error message | Email: NULL  Password: Password1! | Invalid data |
| 1.4 | Wrong credentials entered produce an error message | Email: notreal@gmail.com  Password: FakePass1! | Invalid data |
| 1.5 | Correct credentials successfully log in | Email: kostispapd@gmail.com  Password: Password1! | Will show if correct credentials log the user in to the correct view (admin/student) |

2FA window:

|  |  |  |  |
| --- | --- | --- | --- |
| Test No. | Test | Test Data | Justification |
| 1.1 | Empty field produces an error message | NULL | Invalid data |
| 1.2 | Invalid code produces an error message | Any code that isn’t the correct code | Invalid data |
| 1.3 | Valid code logs user in | Correct code (received when correct login credentials entered) | Will show if the logic works correctly and if the correct window is created |

2.5.2 Admin View

Form Design and Layout

{do diagram}

2.5.2.1 User Interface

I decided to structure the main window of the admin view as follows.



(Figure 12 in evidence)

At the top of the window, there is a tool bar. Clicking on the Account section will open a drop-down menu where the user will be able to create a student account, change their email address and their password. Clicking on the classes section will open a drop-down menu with the option to create or delete a class. When the user clicks sign out, the admin window will be destroyed and the login window will open. Clicking on exit will destroy the admin window and stop the program.

When clicking on the create assignment button the following window (the one on the left) will be created. When clicking the class drop-down menu, the teacher will be able to see all of the active classes that they have created. From there, they will be able to pick which class the assignment gets assigned to. When the date button is clicked, a separate window with a calendar will be displayed. When the teacher picks a date on the calendar and clicks select, the calendar window will be destroyed and the date picked will be displayed in the display box. The cancel button will destroy the window and return you to the main screen. The next button will save the assignment information to the database, destroy the create assignment window and create the window on the right.

On the add question window, the type drop-down menu will display the options “Calculation” and “Standard Answer”. This will affect the layout in the student view. When add question is clicked, the question information is saved to the database, the current window gets destroyed and an identical window is created. When the user is finished with adding questions, the finish button will return them to the main admin window.



(Figure 14 and Figure 15 in evidence)

When the view assignments button in the main admin window is pressed, the following window will be created.



(Figure 16 in evidence)

This window will be using the notebook function of the Tkinter library. I am using this function because it will allow for the user to switch quickly between the assignments and submissions. Both windows will have a list with the respective data. The button labelled “Id” will sort the lists by id in ascending order. The button labelled "Title” will sort the list by title in ascending order. I added this function because it would allow the user to find the assignment/submission they were looking for more efficiently.

2.5.2.2 Validation Rules

2.5.2.3 Key Variables/Data Structures/Classes

2.5.2.4 Algorithms and Pseudocode

2.5.2.5 Test Plan

2.5.3 Student View

Form Design and Layout

UI

Validation rules

Key Variables/Data Structures /Classes

Algorithms and PseudoCode

Test Plan for PART THREE

## 2.6 Stakeholders involvement

Testing plan to inform evaluation

# Chapter Three: Iterative Development and Testing

## 3.1 Introduction

I have split my solution into five main parts. The database, the login, the validation, the admin view and the student view. In this section, I will document the development and testing of the different parts of my solution. All sections of my project will be tested thoroughly and altered accordingly.

## 3.2 Stage 1: Building the Database

To manage and interact with my PostgreSQL database, I am using the psycopg2 library as it is a fast and secure database adapter. Also, it will allow for parametised SQL queries to be used which will prevent SQL injections.

Show it (e.g. Screen printouts)

Test it (e.g. test the databases)

Comment on the result

Show changes/correction and further testing

Feedback from Stakeholder (if appropriate)

Review

## 3.2 Stage 2: Building The Log In

Explain the section of code (e.g. SQLITE3 Code)

Show it (e.g. Screen printouts)

logInMenu.py





Login window UI test

|  |  |  |  |
| --- | --- | --- | --- |
| Test No. | Test Description | Outcome | Evidence |
| 1.1 | Test that the window opens | The window opens successfully | A computer screen shot of a computer code  AI-generated content may be incorrect.  (GIF 1 in evidence) |
| 1.2 | Show password button toggles the password visibility | Button changes the visibility of the password | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 2 in evidence) |
| 1.3 | Exit button closes the window | Exit button closes the window successfully | A screen shot of a computer program  AI-generated content may be incorrect.  (GIF 3 in evidence) |
| 1.4 | Empty fields produce an error message | Error message created when both fields are empty | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 4 in evidence) |
| 1.5 | Empty password field produces an error message | Error message is created successfully when the password field is empty | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 5 in evidence) |
| 1.6 | Empty username field produces an error message | Error message is created successfully when the username field is empty | A screenshot of a computer  AI-generated content may be incorrect.(GIF 6 in evidence) |
| 1.7 | Wrong login information entered produces an error message | Wrong login information entered produces an error message successfully | A screenshot of a computer  AI-generated content may be incorrect.(GIF 7 in evidence) |
| 1.8 | Correct student information entered creates student view | Student view created successfully when correct student information is entered | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 13 in evidence) |
| 1.9 | Correct admin information entered creates the admin/teacher view | The admin view is created successfully when the correct information is entered | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 14 in evidence) |

Feedback

All of the tests were passed successfully so there is no need for any corrections. I showed the UI to my stakeholders and they were also pleased with the result. However, the two-factor authentication system is not a feature. This goes against my success criteria.

Here is the altered logIn.py code with the 2FA system:









This code imports the sendEmaiOTP from the module processWindows.py. This procedure sends an email to the user logging in with their one time password. It uses the email.message library. I chose to use this library as it allows for easy and simple construction of email messages. Also, the email.message library has good integration with the smtplib library which allows Python to send email messages via SMTP servers.

The following code snippet shows the sendEmailOTP procedure. This procedure receives check (all of the user’s information) and the otp as parameters. It then gets the user’s email from the check parameter and crafts the email message using the EmailMessage() procedure (imported from email.message library). It then creates a connection with the SMTP server using the provided port and by logging in to the sender email. Then, it sends an email to the user with their one time password.

processWindows.py snippet:



Two-factor authentication UI test

|  |  |  |  |
| --- | --- | --- | --- |
| Test No. | Test Description | Outcome | Evidence |
| 1.1 | 2FA window opens when correct information is entered | 2FA window gets created successfully when the correct login information is entered | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 8 in evidence) |
| 1.2 | Resend code button sends the same code | When the resend button is clicked, the same code is sent to the user | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 9 in evidence) |
| 1.3 | Invalid 2FA code produces an error message | An invalid 2FA code successfully produces an error message | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 10 in evidence) |
| 1.4 | Valid 2FA code logs the user in to the student view | When a student enters a valid 2FA code, they are logged in to the student view | (GIF 11 in evidence) |
| 1.5 | Valid 2FA code opens admin view when entered by an admin/teacher | The admin view opens when an admin/teacher enters a valid 2FA code | A screenshot of a computer  AI-generated content may be incorrect.  (GIF 12 in evidence) |

Comment on the result

Show changes/correction and further testing

Feedback from Stakeholder (if appropriate)

Review

## 3.2 Stage 3: Building The Validation

In my solution, I will have two types of validation. I will have input validation, which will validate user inputs like passwords and emails, and I will have database validation, which will validate database connections and data.

The following code outlines the input validation.

isValid.py:



Test it (e.g. test the databases)

To test my validation, I will be using the unittest library. {yap}

isValid\_testing.py:



Email validation and verification testing

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test No. | Description | Test data | Expected Outcome | Actual Outcome |
| 1.1 | Attempt to validate and verify a normal email | b32908@sfc.potteries.ac.uk | “True True”  “True True” | A computer screen with white text  Description automatically generated |
| 1.2 | Attempt to validate and verify an invalid email | b32908@uk | “False False” “False False” | A screen shot of a computer  Description automatically generated |
| 1.3 | Attempt to validate and verify a valid but not real email | b32908@uk.com | “True True”  “False False” | A screenshot of a computer error  Description automatically generated |

The verification on test 1.3 failed. The expected outcome should be false as the email address doesn’t exist but the email verification returns True. Upon further inspection of my code and the Kickbox API documentation, I discovered that the problem had to do with the API key. When I set up the API key, I configured it incorrectly and it simulated every test that I tried. This meant that all the results I was given were fake. To fix this, I created a new API key with the correct configuration. This change only affects the subroutine verifyEmail().



The tests for the new code are outlined below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test No. | Description | Test data | Expected Outcome | Actual Outcome |
| 2.1 | Attempt to validate and verify a normal email | b32908@sfc.potteries.ac.uk | “True True”  “True True” | A screenshot of a computer  Description automatically generated |
| 2.2 | Attempt to validate and verify an invalid email | b32908@uk | “False False” “False False” | A computer screen with red text  Description automatically generated |
| 2.3 | Attempt to validate and verify a valid but not real email | b32908@uk.com | “True True”  “False False” | A black screen with white text  Description automatically generated |

{yap}

I then tested the password validation. Each password should have 8-20 characters, upper and lowercase characters, symbols and numbers. The tests went as follows:

Password validation testing:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test No. | Description | Test data | Expected Outcome | Actual Outcome |
| 1.1 | Attempt to validate a valid password | passwA!or33345 | “True True” | A screen shot of a computer  Description automatically generated |
| 1.2 | Attempt to validate a password with no uppercase letters | password1! | “False False” |  |
| 1.3 | Attempt to validate a password with exactly 8 characters | Pass1!rd | “True True” | A black screen with white text  Description automatically generated |
| 1.4 | Attempts to validate a password with less than 8 characters | Pass1!r | “False False” | A screen shot of a computer  Description automatically generated |
| 1.5 | Attempts to validate a password with exactly 20 characters | PasswordLengthTest1! | “True True” | A black screen with white text  Description automatically generated |
| 1.6 | Attempts to validate a password with more than 20 characters | PasswordLengthTest1!! | “False False” | A computer screen shot of a test  Description automatically generated |
| 1.7 | Attempt to validate a password with no lowercase letters | PASSWORD1! | “False False” | A screen shot of a computer  Description automatically generated |
| 1.8 | Attempt to validate a password with no symbols | Password1 | “False False” |  |
| 1.9 | Attempt to validate a password with no numbers | Password! | “False False” | A black screen with white text  Description automatically generated |

I am happy with the password validation testing. All tests passed successfully and no code had to be altered.

My database validation mostly consists of try, except statements. These statements ensure that if the database does not connect to the program, there is an error box instead of a syntax error.

Feedback from Stakeholder (if appropriate)

Review

## 3.2 Stage 4: Building The Admin View

Explain the section of code (e.g. SQLITE3 Code)

Show it (e.g. Screen printouts)

Test it (e.g. test the databases)

Comment on the result

Show changes/correction and further testing

Feedback from Stakeholder (if appropriate)

Review

## 3.2 Stage 5: Building The Student View

## 3.3 Final Review, Improvements and Corrective Actions

I also tested if the UI of the application displayed correctly on different operating systems. I tested my UI on Windows 11 and a Linux based system.

|  |  |  |
| --- | --- | --- |
| Windows | Linux | Outcome |
|  | A screenshot of a computer login  AI-generated content may be incorrect. |  |
|  | A screenshot of a computer security  AI-generated content may be incorrect. |  |
|  | A screenshot of a computer  AI-generated content may be incorrect. |  |
|  | A screenshot of a computer  AI-generated content may be incorrect. |  |
|  | A screenshot of a computer  AI-generated content may be incorrect. |  |
|  | A screenshot of a computer  AI-generated content may be incorrect. |  |
|  | A screenshot of a computer  AI-generated content may be incorrect. |  |

# Chapter Four: Evaluation

Evaluation

## 4.1 Introduction

## 4.2 Testing to inform evaluation

## 4.3 Evaluation

Evaluating usability features

Evaluating Robustness

Limitations and Maintenance