DECLARATION

I William Marco Kotta, hereby declare that this report is my own work and effort and that it has not been submitted to any University for a similar award. The work in this report was carried out in accordance with the regulations of Ardhi University and has not been presented to any other University for examination either in Tanzania or elsewhere. Where other sources of information have been used, they have been shown in the references lists.

William Marco Kotta	……...	…….
Name of student	Signature	Date

CERTIFICATION

The undersigned certifies that has read and hear by approves for acceptance the Ardhi University a dissertation proposal titled "**SMART SCHOOL BELL WITH TIMETABLE DISPLAY**" in fulfillment of the requirements for the degree of Bachelor of Science in Computer System and Network of Ardhi University.

Supervisor(s):	**Signature**	**Date**
1. Mr. Evarist Alexander	……...	…….
2. Mr. Yohana Kangwe	……...	…….

ABSTRACT

This paper presents a novel Smart School Bell System with Timetable Display. The smart school bell system is designed using NodeMCU ESP8266, Arduino IDE, Circle Bell, one-way Relay Module, Breadboard, Jumper Wires, NTP protocol, Firebase, and Thing Speak. This system also includes an LCD 20x4 and a mobile application built using Kodular web application for designing an Android application. The system utilizes the internet to access a database on Firebase and Thing Speak to store bell schedules and other important information.

The mobile application allows the user to control the bell remotely and monitor the bell schedule in real-time. This system provides an efficient and automated way to manage school bells, making it easier for time keeper to focus on their subjects without worrying about ring the bell schedules. The system aims to replace the traditional school bell system with an automated and intelligent one, enabling a more flexible and efficient way of managing class schedules. The proposed solution includes a mobile application that allows administrators to manage the bell system and for students to receive real-time notifications and timetable display about class schedules. The system integrates with Firebase for database management and Thing Speak for data visualization. The project aims to enhance the school's overall efficiency, reduce human error, and provide a better learning experience for students.

To achieve this overall aim of developing an android application which would enhance communication between staffs and students in school bells, the aim was broken down into four measurable (aggregate) steps using the waterfall methodology. The first step was requirement gathering (data collection) which was done using the questionnaires and interviews. The second step followed the analysis of the data collected which was performed with google forms. Afterwards, design of the system was done using Object Oriented Analysis and Design Methodology (OOADM), specifically, the UML (Unified Modeling Language). The next step was implementation whereas the system was the implemented and lastly the system was tested in terms of functionality (functional testing; testing the system against its functional requirements) as well as user-acceptance testing.

ACKNOWLEDGEMENT

I would like to provide my sincerely and inner gratitude to our Almighty for giving healthy and courage throughout the research project training period. I would like to express my special thanks to my supervisors for their kind co-operation and encouragement which helped us in completion of this dissertation and for their technical advice towards accomplishment of this research proposal report. Finally, I thank Precious high school at Dar es salaam for support during the gathering of information for my research proposal report through google form.

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LIST OF ABBREVIATIONS AND ACROYNMS

IOT	Internet of Things
IC RTC DS1307	Integrated Circuit Real Time Clock
LCD	Liquid Crystal Display
GSM	Global System for Mobile Communications
SSID	Service Set Identifier
PASS	Password
WI-FI	Wireless Fidelity
OOAD	Object-Oriented Analysis and Design
UML	Unified Modeling Language
IDE	Integrated Development Environment
PHP	Hypertext Preprocessor
TCP/IP	Transmission Control Protocol/Internet Protocol
ESP8266	Embedded Systems Processor
USB	Universal Serial Bus
IOS	iPhone Operating System
SDK	Software Development Kit
APK	Android Package Kit
UAT	User Acceptance Testing

CHAPTER ONE

1.0 INTRODUCTION

1.1 General Introduction

Smart school bell with timetable display is a system that automates the ringing bells in the school to signal the start and end the class periods, breaks, and other events with timetable monitoring display. (Gang, 2008) Some possible application for smart school bell includes automating the bell schedule, customizing the bell schedule, improving communication and enhancing security.

The study by (Nanili, 2020) on IOT based wireless automated bell ringing system in an institution. The Journal of creative behavior. volume 8. 2320-2882. The main objective of this project is to implement an Automatic college bell ringing system. In this project, there are four major components which are IC RTC DS1307, Arduino uno Board, 16x2 LCD modules and input provision to change the timing during Exam hours. Here, the code is designed in such a way that the bell will be activated for every 50 minutes as per the college schedule, the bell will continue to ring for 10 seconds in every block of our college simultaneously by transferring the information through RF module, which indicates the students and faculty about the completion of a particular session in all the blocks in a simultaneous manner.

Another study by (Aliyu, 2017) proposed a GSM-based school bell system that can be used to control the ringing of the school bell and display the timetable on a monitor. Their system was able to reduce the cost of manual labor associated with the manual ringing of the bell and displaying the timetable.

The gap that system would like to fill in with a smart school bell with timetable display is the ability to integrate the system with existing school infrastructure, such as the school's computer network, to provide a more efficient and automated way of managing the school bell and displaying the timetable. Additionally, would also like to explore the potential of using web based and mobile application to automate the scheduling process and to provide better user experience used to configure the system by inserting timetable of the school, breaks, events, the time delay for ringing bell, and configuring SSID and PASS of the router or wi-fi technology, so as to reduce manual ringing of the bell with IOT features to be useful for all Government, Private and International school (Commission, 2014).

1.2 Statement of the Problem

The current system of ring the bell in different schools involve the pupils or student who is selected among the school pupils or student. The student is named as time keeper and he or she always needed to be out of the class to ring the bell few minutes before the end of the session (period) to alert the teachers and student or pupils what is the next event (Fan, 2013). Traditional and current situation is that the traditional system has a distraction, the student is not paying attention to his studies, he has to ring the bell every time the bell required to ring, also current situation the bell rings but without showing what events are at that time.

The traditional system of school bells in Tanzania is inefficient and outdated. The current situation has led to issues such as late arrivals, disruption of classes, and lack of communication between school authorities and students (Cailong, 2016). A solution to this problem is to implement a modern, automated system of smart school bells that can be controlled remotely and provide real-time notifications and updates. This will improve the overall efficiency of the school system and ensure that students arrive on time and are kept informed of upcoming events.

The purpose of the proposed study is to improve current system for smart school bell with timetable monitoring display that would enhance communication and information flow between students and teachers by storing entire day timetable with timings, displaying the current and the next event and ability to reprogram the board at any time.

1.3 Objectives

1.3.1 General Objective

The general objective of this research is to develop smart school bell with timetable display.

1.3.2 Specific Objectives

i. To identify and gathering user requirements for smart school bell system.
ii. To design system for smart school bell that meets the user's needs.
iii. To implement smart school bell that meets the user's needs.
iv. To test and validate the system for smart school bell.

1.4 Research Questions

i. What are specific requirements of users for smart school bell system?
ii. What are technical requirements for designing smart school bell system with timetable display?
iii. How can smart school bell with timetable display improve the management and organization of a school's daily schedule?
iv. What are the security and privacy concerns associated with developing smart school bell with timetable display in a school setting?

1.5 Significance of study

The study provides benefits for both students and teachers through automating the ring bells in school to signal starting and ending the class periods, breaks and other events. This study provides real time updates on class schedules and other important information. In addition, the use of smart school bell with time table display can improve communication and collaboration between teachers, students and parents. For example, easy way for parents to stay informed about their child's class schedule and any changes that may occur. Additionally, the display feature allows announcements from discipline officer and headmaster to be displayed (Yuan, 2012).

1.6 Structure of the report

The following content describes how this entire report is broken down into chapters and briefly what each chapter contains.

Chapter one: Introduction. This chapter as the name suggests, introduces what this dissertation is all about. It includes the background of this dissertation, the statement of the problem, general objective, specific objectives, research questions, significance of the study, scope of the study, limitation of the study, definition of some terms used in the report as well as the road map of this entire proposal.

Chapter two: Literature review. This chapter provides explanation on key terms of the dissertation according to different researchers and the importance of this study more critical with references to different researches. Most importantly, this chapter presents critical analysis of the literature which is relevant to this area of study by showing what these researchers have done in this field of study as well as the gaps left out of which are going to be filled with this study.

Chapter three: Methodology. From this chapter, one may find the methodologies and tools used in delivering each stated specific objective.

Chapter four: Design. This chapter provides the analysis and design methodology used among other methodologies as well as the designs for the system before its actual implementation.

Chapter five: Implementation and Testing. This chapter entails the system output as well as how the system was tested, and testing results obtained.

Chapter six: Results and Discussion. This chapter provides findings (products and experimental findings), goals achieved but most importantly, future works which may be the new areas of investment or a gap in the solution that may be further studied and solved.

Chapter seven: Summary, Conclusion and Recommendation. This chapter provides a summary for the whole dissertation which includes important stages into achieving the general objective as well as the outcome from the dissertation. The chapter also presents conclusion for the dissertation and recommendation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

A literature review of the smart school bell with a timetable display system is presented in this paper. It provides an overview of the current state of the technology, the various approaches used to implement such a system, and the advantages and disadvantages of each approach. The review also considers the potential applications of the system in the educational context, including its potential to improve student attendance, reduce teacher and administrative workloads, and provide a more efficient way of managing school activities. Finally, the paper outlines some of the challenges facing the development and implementation of the system and suggests potential solutions.

2.2 Current state of the technology

The Current state of the technology of the literature review for the smart school bell with timetable display system is in its early stages of development. While some early adopters have implemented such systems in their schools, much of the research is still ongoing. Studies have been conducted to assess the effectiveness and feasibility of such systems, as well as their impact on student engagement and academic performance. Research has also identified potential challenges and benefits associated with implementing such systems. Additionally, researchers have proposed various technological approaches to the design of a smart school bell with a timetable display system and these have been evaluated through simulations and field studies. At present, the technology of literature review for the smart school bell with timetable display system is still in its infancy (Khanna, 2012).

2.3 Related works

The following are some works related to the area of the study, how they differ from this study as well as the research gap between;

2.3.1 Advantage and disadvantage of each approach

The study by, (Nanili, 2020) on IOT based wireless automated bell ringing system in an institution implement an Automatic college bell ringing system. In this study there are four major components which are IC RTC DS1307, Arduino uno Board, 16x2 LCD modules and input provision to change the timing during Exam hours. Here, the code is designed in such a way that the bell will be activated for every 50 minutes as per the college schedule, the bell will continue to ring for 10 seconds in every block of our college simultaneously by transferring the information through RF

module, which indicates the students and faculty about the completion of a particular session in all the blocks in a simultaneous manner. The authors found that the use of this system reduces the time taken for the transition between classes by up to 15%. Further, the system has the potential to reduce the number of students late for classes and increase overall student engagement during the school day. The authors also identified potential disadvantages associated with the system, such as the potential for misuse, increased student distraction, and the potential for cyberbullying. Overall, this study provides a comprehensive review of the advantages and disadvantages of the smart school bell with timetable display system and provides valuable insight into the potential implications of using this system in schools.

The study by, (Aliyu, 2017) proposed a GSM-based school bell system that can be used to control the ringing of the school bell and display the timetable on a monitor. Their system was able to reduce the cost of manual labor associated with the manual ringing of the bell and displaying the timetable. The disadvantage of this system is that it could be costly to implement and maintain. Additionally, there is lack of privacy and security when using a digital system to display and manage sensitive information.

2.3.2 Research gap

The gap that system would like to fill in with a smart school bell with timetable display is the ability to integrate the system with existing school infrastructure, such as the school's computer network, to provide a more efficient and automated way of managing the school bell and displaying the timetable. Additionally, would also like to explore the potential of using web based and mobile application to automate the scheduling process and to provide better user experience used to configure the system by inserting timetable of the school, breaks, events, the time delay for ringing bell, and configuring SSID and PASS of the router or wi-fi technology, so as to reduce manual ringing of the bell with IOT features to be useful for all Government, Private and International school (Commission, 2014).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Discussion on the selected methodology

A methodology may be defined as a sequence of step-by-step approaches that are used in developing a product (Josette, 2017)There are a number of software development methodologies. A software development methodology also called software development lifecycle or process has been defined as a comprehensive, multiple step approaches to systems development that will guide your work and influence the quality of your final product, which is an information system. (Alan, H, & Roth, 2012)

Table 1 Methodology

S/No	Specific objective	Methodology	Tools	Deliverables
1	To identify and gathering user requirements for smart school bell system.	Literature review, questionnaire and interview	Literature, Google form	Analytical report
2	To design system for smart school bell that meets the user's needs.	Object Oriented Analysis and Design (OOAD): Unified Modelling Language (UML) diagrams	Draw io	Systems designs
3	To implement smart school bell that meets the user's needs.	Modified waterfall methodology	Android with java, PHP, ArduinoIDE,Thingspeak and Firebase database.	Mobile and Web based Application

4	To test and validate the system for smart school bell.	Beta test	Android smart phone, laptop,NodeMCU, lcd20x4, Circle bell, Arduino IDE, relay module. Jumper wires	Mobile and Web based Application

3.2 Data collection methods

Data may be defined as raw streams of facts. They are called raw because they are not yet processed and they are to be useful after being processed. As the first specific objective states; gathering requirements meaning collecting data. Data was collected from both sides; teachers and parents of nursery pupils. Analysis of the data collected enabled the establishment of requirements for the system (Winslow, 2012). The following are the methods used in collecting data needed for the accomplishment of this dissertation;

3.2.1 Questionnaire

This is a data collection method which consists of set of questions printed or online. These questionnaires were prepared and supplied to teachers through Google forms. They were self-administered and online which helped in minimizing cost and increasing efficiency in data collection (Zehra, 2016). They were distributed via WhatsApp and email. The reason as to why questionnaires were used is to understand the overall perception of teacher on the current communication methods for example Precious high school at Dar es salaam and the new android application as well as gathering requirements for the new application for smartschoolbell. The questionnaires were also used for interviewing people

3.2.2 Interview

This is another data collection method which was used to obtain data in deep and to gain a more understanding on people's perception on current communication methods and introduction of this mobile application specifically for each person. Questionnaires were used only as a guide for the questions. Some answers from interviewees led to further questions and even more details. At the school's (teachers') side, this was the only data collection method used (Paradkar, 2017). Interview is a method that was also used to collect relevant information about school schedule which data

was collected from (Wang, 2013). Through Google form also three teachers from three different nursery schools were interviewed and obtain total of 20 responses.

3.2.3 Analysis of Results

The analysis of results was done using Google forms. Since the answers from interviews were guided by the questionnaires; they were also filled in Google forms together with the questionnaires. The total number of teachers asked was 20 and the total number of schools from where data was collected was 3 schools.

CHAPTER FOUR

4.0 SYSTEM DESIGN

4.1 Introduction

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. It is the process of defining, designing, testing, and deploying a software system. It involves making decisions about how to organize software components, how to communicate between different components, and how to handle data storage and processing (C.Martin, 2018). Development of a system is a systematic process which includes a number of phases namely; planning, analysis, design, deployment (implementation), testing and maintenance. System analysis is a phase in the system development life cycle which involves collecting and interpreting facts, identifying problems and decomposing a system into its components. System analysis is conducted for the purpose of understanding a system with its parts as well as to identify objectives. Therefore, a systems analysis may be viewed as a problem-solving technique which improves and ensures that all system components work effectively, efficiently and accomplish their purpose

4.2 System Requirements

System requirements include all tools and data that were required for the development of the system. The requirements were data, hardware and software and are explained as follows:

4.2.1.1 Data requirements

These include all data that was needed for implementation of the system. Data needed was the information content that is transferred between staffs and students from current school bell and corresponding bell schedule (SmartBear, 2019). This data was collected from the questionnaires and interviews conducted during data collection.

4.2.1.2 Hardware requirements

All the hardware required for the android application and IOT development is all explained under this section, requirement for the development for smartschoolbell were:

i. NodeMCU ESP8266 Module:

It is a small-sized, low-cost Wi-Fi module with an inbuilt ESP8266 chip, which can be programmed using the Arduino IDE. It provides Wi-Fi connectivity and allows the school bell to be controlled remotely over the internet. NodeMCU is an open-source firmware and development

board based on the ESP8266 Wi-Fi chip. The ESP8266 is a low-cost, low-power Wi-Fi microchip with full TCP/IP stack and microcontroller capabilities, making it ideal for Internet of Things (IoT) projects (Zanella, 2014).

NodeMCU provides a simple and easy-to-use platform for prototyping IoT projects, allowing developers to quickly build Wi-Fi enabled devices without the need for extensive hardware or software knowledge. Its small form factor and built-in USB-to-serial converter also make it easy to program and connect to other devices.

Overall, NodeMCU and the ESP8266 are popular choices for building connected devices due to their low cost, ease of use, and versatility.

ii. Circle Bell:

It is a type of bell that can be used to produce sound for the school bell. One reason why the Circle Bell has become popular is because it is a smart device that can be easily controlled and programmed through a mobile app or web interface. This allows school administrators to schedule different bell tones for different times of the day, and to customize the bell schedule to meet the needs of their school.

Another reason why the Circle Bell is popular is because it provides a range of additional features that can help schools operate more efficiently. For example, the Circle Bell can be programmed to automatically adjust the bell schedule to account for unexpected events such as school closures or early dismissals. It can also be used to broadcast announcements or emergency messages throughout the school.

iii. Relay Module:

It is an electronic device used to control high voltage, high current loads such as the school bell. It is also used to isolate the low-voltage signal from the NodeMCU ESP8266 (Spagnuolo, 2022.).

iv. Breadboard:

It is a tool used for prototyping and building electronic circuits without the need for soldering (Ouedraogo, 2022).

v. Jumper wires:

They are used to connect various components on the breadboard to each other.

vi. LCD 20X4:

It is a type of display that can be used to show the current status of the school bell, such as the current time and the schedule of the next bell.

4.2.1.3 Software requirements

i. Arduino IDE:

It is an open-source software development platform used to program NodeMCU ESP8266, which can be downloaded from the official Arduino website. Arduino IDE is an integrated development environment (IDE) used for writing, compiling, and uploading code to Arduino microcontrollers. The Arduino IDE is designed to be user-friendly and easy to use, even for beginners who have no experience with programming.

The Arduino IDE is a popular choice for programming Arduino boards because it provides a simple and intuitive interface that enables users to quickly develop and test their code. The IDE also includes a number of useful features, such as a code editor, a serial monitor for debugging, and a library manager for easily adding external libraries to your project.

Additionally, the Arduino IDE is open-source and freely available, which means that it can be used by anyone for personal or commercial purposes without any licensing fees or restrictions. This has made it a popular choice among hobbyists, students, and professionals alike who want to develop embedded systems and other projects using Arduino microcontrollers (Toosi, 2021).

ii. Firebase:

It is a cloud-based database platform used to store and retrieve data in real-time. It can be used to store the school bell schedules, which can be accessed remotely (Norris, 2015).

iii. Thing Speak:

It is an IoT platform that allows the school bell to communicate with the internet and send data to the cloud, such as the current status of the bell (Ashton, 2018).

iv. Mobile Application with Kodular:

Kodular is a web-based platform used to design and build mobile applications with block coding integrated development environment originally provided by Google, and now maintained by the Massachusetts Institute of Technology. It can be used to design the mobile application for controlling the school bell remotely and link with cloud-based database to the IOT electronics devices.

Why Kodular, because facilitates connection in the IOT infrastructure, allowing for easy integration of hardware devices, APIs, and online services with support of all MIT app inventor.

In summary, the above components are used to build a smart school bell that can be controlled remotely over the internet using a mobile application. The NodeMCU ESP8266 provides Wi-Fi connectivity and is programmed using the Arduino IDE. The bell is controlled using a 2-way relay module, and the schedules are stored in Firebase. The Thing Speak platform is used to send data to the cloud, and the LCD display shows the current status of the bell. Finally, the mobile application is designed using Kodular (Hermes, 2019).

4.2.2 User Requirements

These are what users require from the system. The user requirements may be functional and non-functional requirements and are well explained as follows

4.2.2.1 Function Requirements

In software engineering and system development, a functional requirement refers to a specific task or function that a system or software application must perform to meet the needs of its users.

These requirements define the intended behaviour of the system or application, such as specific input requirements, processing rules, output requirements, and other constraints. The functional requirements of this system are (Wiegers, 2003):

i. The system should provide User Authentication: The app should allow users to create an account and log in to access the features of the app.
ii. The system should enable Event Selection: The app should allow the user to select an event from a list of available events. These events could include school periods, breaks, assembly, or any other relevant event.
iii. The system should enable Teacher Name Selection: The app should allow the user to select the name of the teacher who will be responsible for that event.

iv. The system should provide Date and Time Selection: The user should be able to select the date and time when the event starts and ends. This information will be used to set the school bell schedule.

v. The system should provide Node MCU Integration: The app should be integrated with the Node MCU device, which will be used to control the school bell system. The app will send the selected event, teacher name, start time, and end time to the Node MCU through the IoT cloud Firebase database and Thing speak for helping to display only event to the lcd20X4.

vi. The system should enable IoT Cloud Integration: The app should integrate with the IoT cloud Firebase database to store and retrieve data. This will allow the app to communicate with the Node MCU device in order to monitor and display school schedule and ringing the school bell.

vii. The system should provide sound notification system: The app should send notifications to the teacher's device when their event is about to start. The notifications should include the name of the event, start and end times, audio through the phone and school bell device.

viii. The system should provide setting for school admin or headmaster Panel: The app should have an admin panel that allows school administrators to add and remove events, update the schedule.

ix. The system should enable Monitoring Display: The app should trigger event to LCD 20X4 which controlled by Node MCU when action of event performed. E.g. Period 1: Maths or Breakfast. The Thing Speak platform is used to send data to the cloud, and the LCD display shows the current status of the bell and Digital clock from NTP client protocol. Finally, the mobile application is designed using Kodular Platform which act as Android studio online tool (Davis, 2016).

x. The system should provide Multi-Platform Compatibility: The app should be compatible with multiple platforms, including Android and iOS, to ensure that all users can access the features of the app with minimum of Increased Minimum SDK to 21 or Android 5.0: lollipop (Iversen, 2013).

4.2.2.2 Non-Function Requirements

Non-functional requirements are the characteristics or attributes of a system that describe how the system behaves, rather than what the system does. They typically describe aspects such as

performance, scalability, security, usability, reliability, and maintainability of the system (S. McConnell, 1998.)

The following were the non-functional requirements for the system;

a) Scalability: This could include the system's ability to handle increasing amounts of data or users without affecting its performance or reliability.
b) Availability: The system can be accessed anytime in a day including weekends and school holidays.
c) Reliability: The system provides features such as splash screen and no internet splash screen motivate to assign if there is no efficient network communicate between cloud database and android application.
d) Maintainability: This could include how easy the system is to maintain and modify.
e) Security: This could include measures to protect the system against unauthorized access.

4.3 System design

4.3.1 System architecture

System architecture refers to the overall design of a system, including its components, structure, interactions, and interfaces. It provides a blueprint for building and maintaining a system that meets the desired functional and non-functional requirements. (Xiao, 2018). Below was the system architecture for the system;

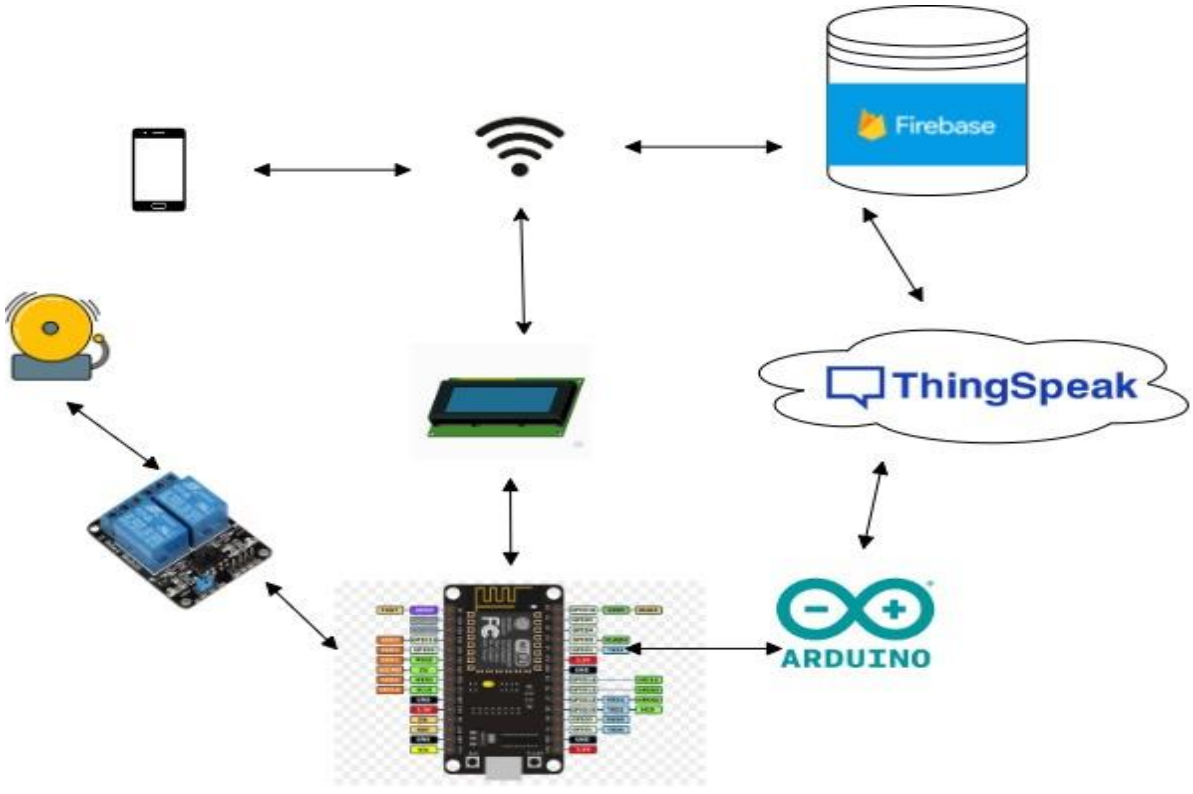


Figure 4.1 System Architecture

4.3.2 Flow chart

A flowchart is a graphical representation of a process or system, showing the sequence of steps or activities and the decision points along the way. It is a useful tool for visualizing complex processes and identifying areas where improvements can be made. A flowchart typically uses standardized symbols and shapes to represent different types of activities, decisions, and inputs or outputs. Common symbols used in flowcharts include rectangles (for process steps), diamonds (for decision points), and arrows (for indicating the flow of activities). (Institute, 2000).Below was the flowchart for the system;

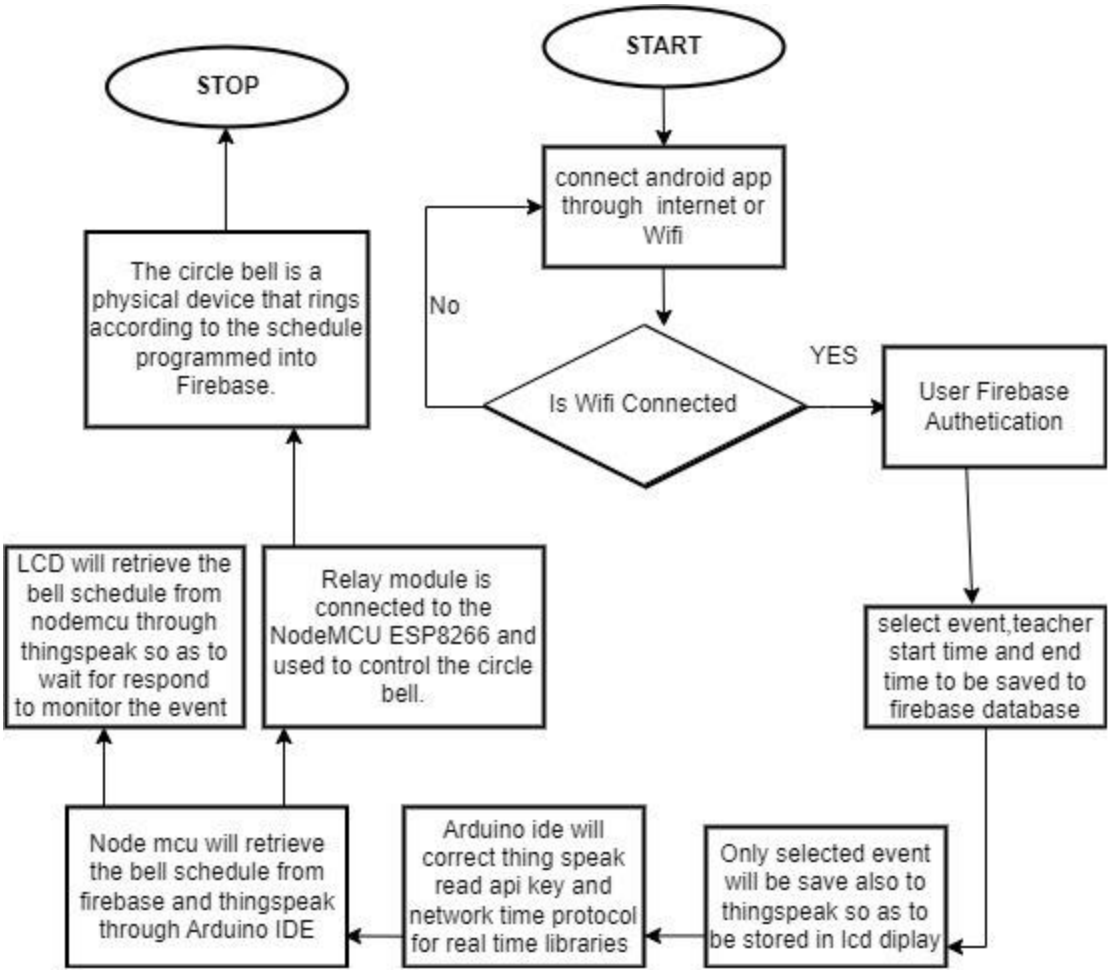


Figure 4.2 Flow chart

4.3.3 Sequence diagram

A sequence diagram is a type of UML (Unified Modelling Language) diagram that shows interactions between objects or components in a system or software application. It represents the flow of messages between objects over time, and is useful for visualizing the dynamic behaviour of a system. (Fowler, UML Distilled, 2004). Below was the sequence diagram for the system;

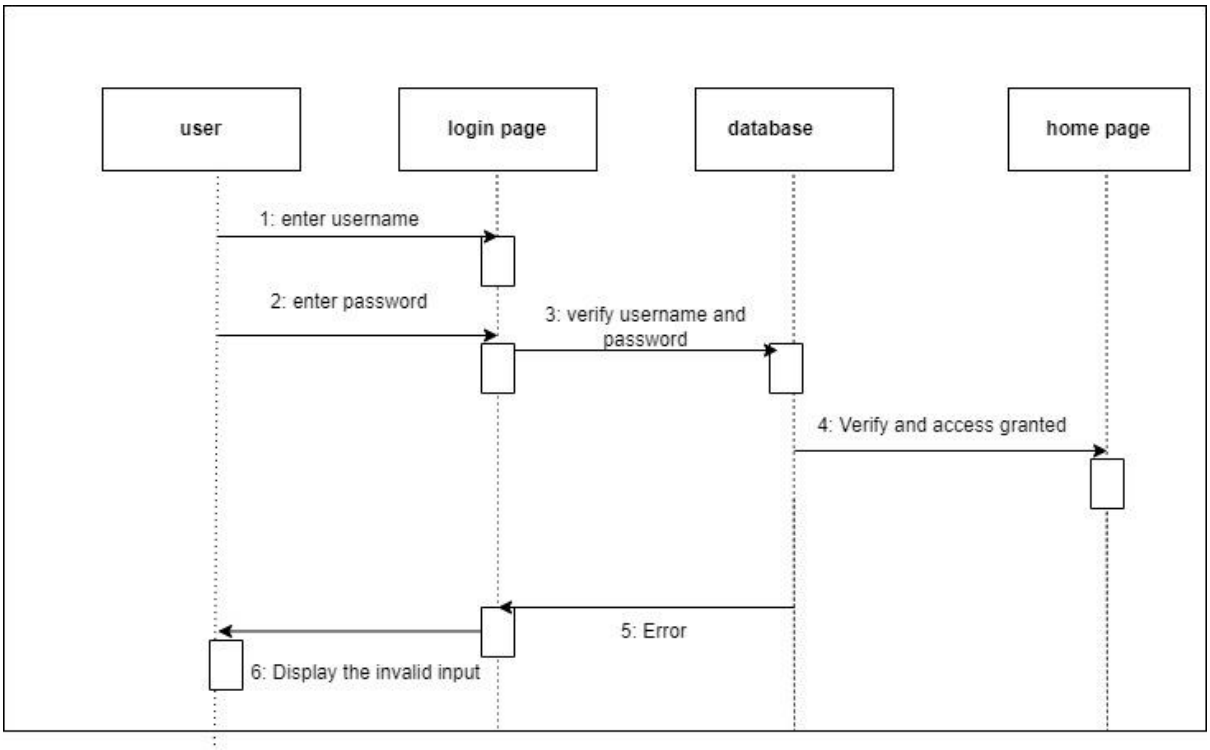


Figure 4.3 Sequence Diagram for Login form

4.3.4 Use case diagram

A use case diagram is a graphical representation of the interactions between an actor (user) and a system in a specific context or scenario. It is a type of behavioural diagram that is often used in software engineering and systems analysis to describe the functional requirements of a system.

In a use case diagram, the actors are represented by stick figures, and the use cases (functional requirements) are represented by ovals. The interactions between the actors and the use cases are shown by arrows. (Fowler, UML Distilled, 2004) Below was the use case diagram for the system;

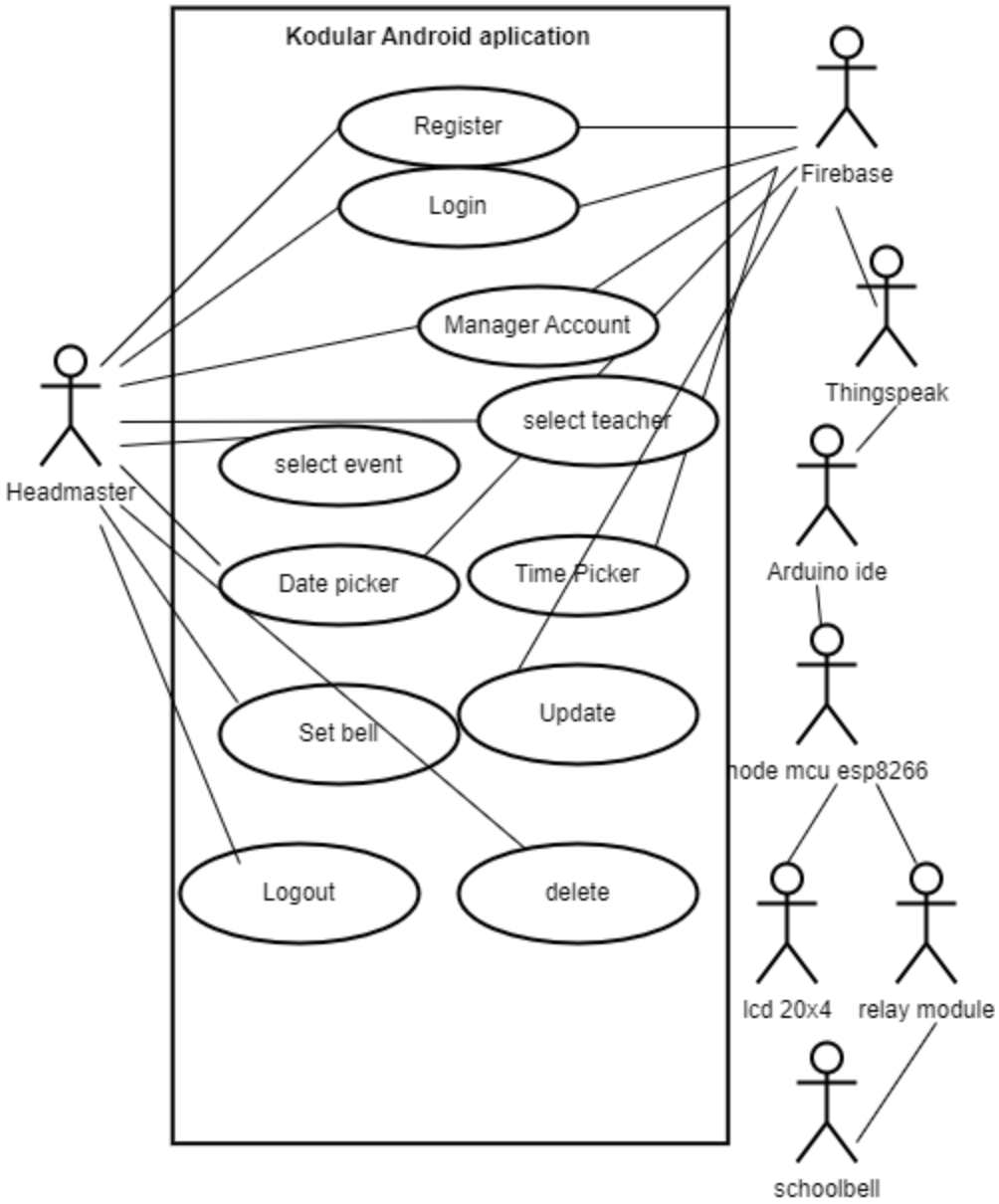


Figure 4.4 Use case diagram

4.3.5 Activity diagram

This is a very important UML diagram, actually stated as the most important UML diagram for doing business modeling. This is the second UML diagram drawn for the analysis and design of the system. This diagram was drawn so as to document the program flow by describing the activities in the system, which are responsible for these activities and the overall flow of these activities. (Fowler, UML Distilled, 2004). Below was the activity diagram for the system;

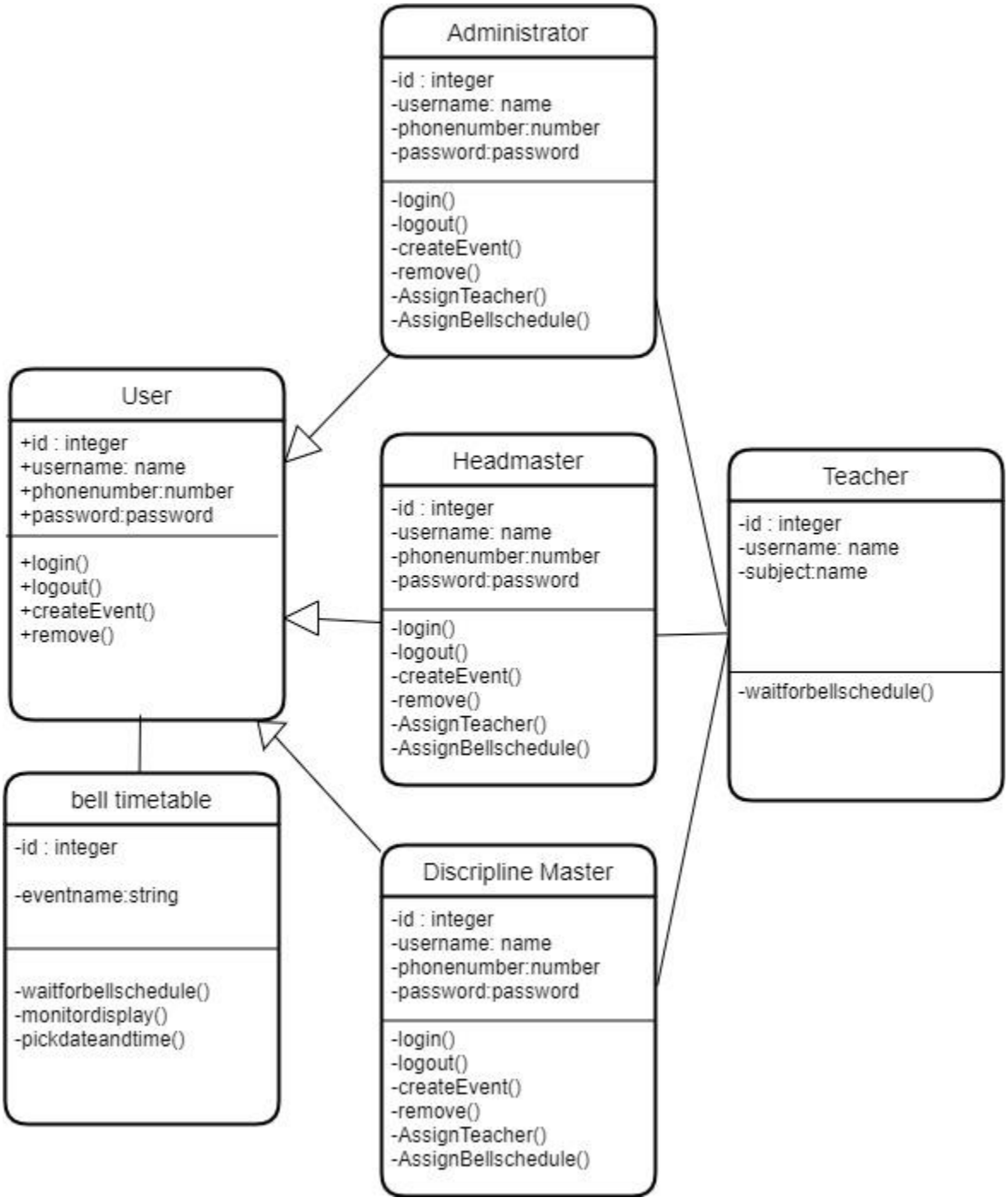


Figure 4.5 Activity Diagram

CHAPTER FIVE

5.0 IMPLEMENTATION AND TESTING

5.1 Introduction

This chapter provides an overview of the smartschoolbell system and its key components, including the web portal, Kodular mobile application, and cloud databases. Furthermore, this chapter describes the system's testing results in both cases; the functional and user-acceptance testing results are evaluated. It also entails the web portal that was designed specifically for the administrator who has been considered as the school admin in the web application and also android application. Traditional methods often result in inconsistencies and time-consuming manual processes. To address this issue, we introduce the smartschoolbell system, a comprehensive solution that leverages modern technologies to automate timetable management and bell scheduling in educational institutions (Nise, 2014).

5.2 SmartSchoolBell System Architecture

The SmartSchoolBell system consists of three main components: the web portal, the Kodular Android application, and the cloud database. These components work together to provide a seamless and efficient solution for timetable management and bell scheduling (Moroney, The Definitive Guide to Firebase: Build Android Apps on Google's Mobile Platform, 2017).

5.2.1 Web Portal

The web portal serves as the central hub for administrators, teachers, and staff to manage timetables, bell schedules, and other related information. It offers a user-friendly interface with various features, including timetable creation, modification, and apk publishing. Administrators can assign subjects, room, start time and end time and also define bell schedules, and The web portal also facilitates communication between administrators and teachers, allowing for efficient coordination and updates (Cheng, 2018).

5.2.1.1 Signup Activity

The Administrator Signup activity for SmartSchoolBell is an essential step to create an account and gain access to the administrative features of the SmartSchoolBell platform. As an administrator, you will have the authority to manage and control various aspects of the school's bell system efficiently.

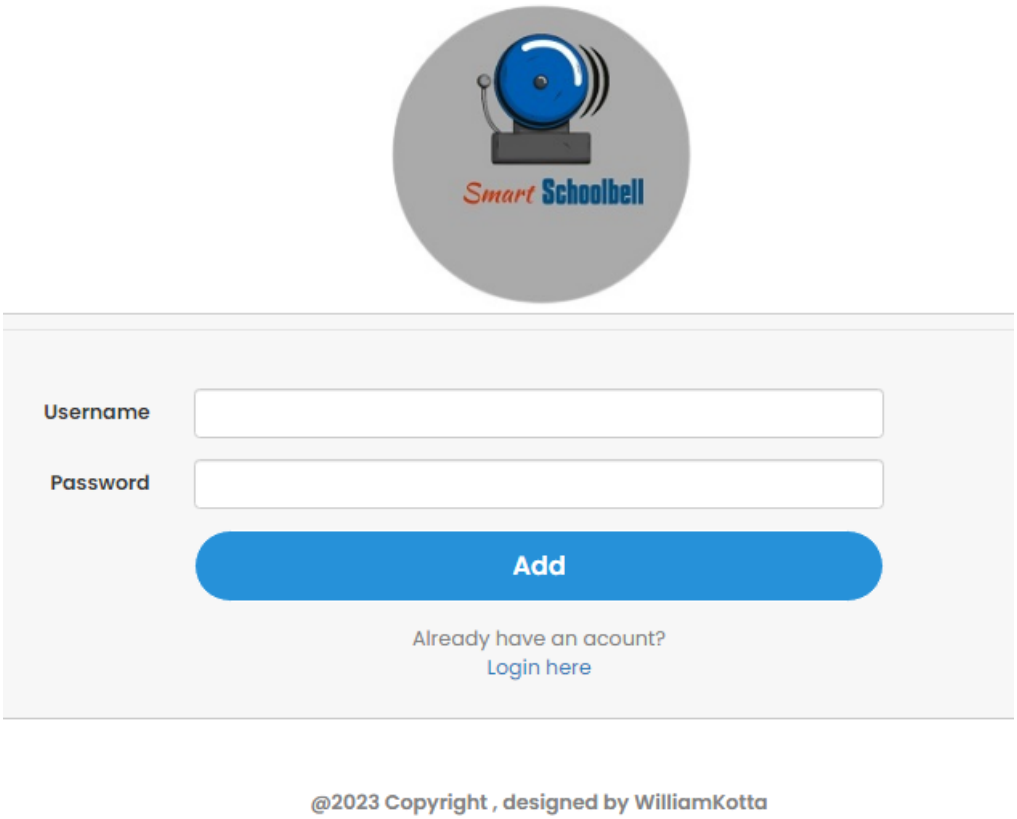


Figure 5.6 Signup Activity

5.2.1.2 Login Activity

After your account has been verified and activated, you can log in to the administrator dashboard using the credentials (username and password) you created during the signup process.

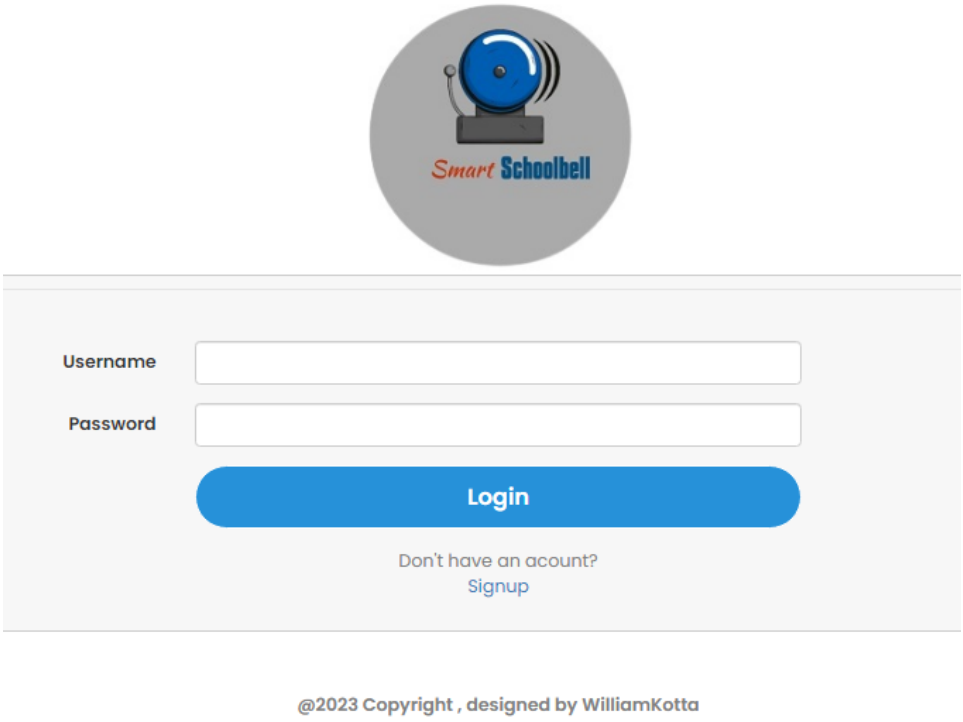


Figure 5.7 Login Activity

5.2.1.3 Home Activity

Smart School Bell administration home page. Here, as an administrator, you can manage the activity schedule for the school, including subjects, rooms, start times, and end times.

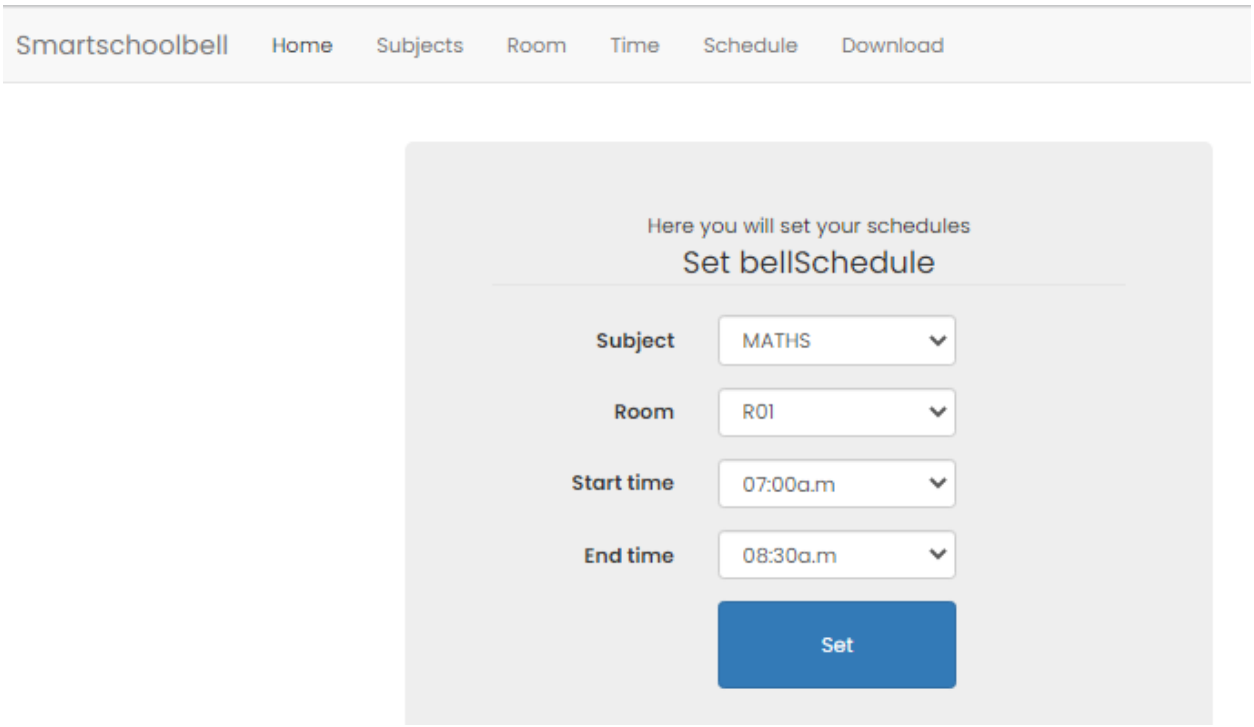


Figure 5.8 Home Activity

5.2.1.4 Subject Activity

Here, as an administrator, you can manage the activity schedule for the subjects includes subject code and subject descriptions.

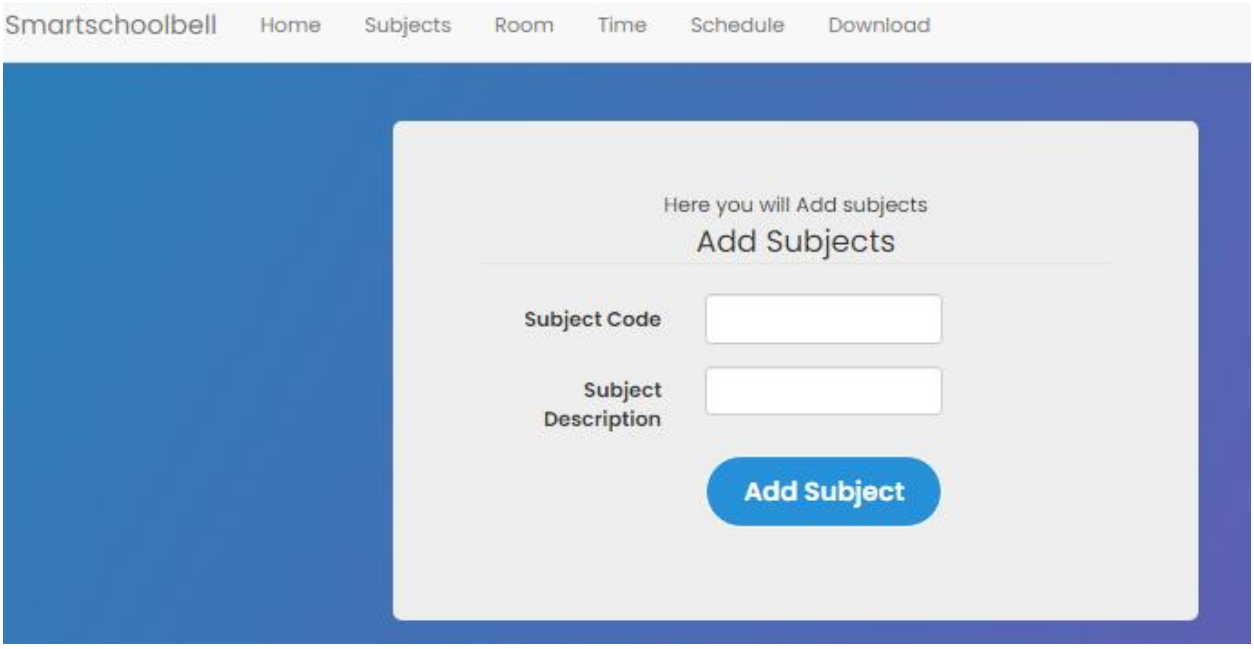


Figure 5.9 Subject Activity

5.2.1.5 Room Activity

Here, as an administrator, you can manage the activity schedule for the room number with specific code number for room.

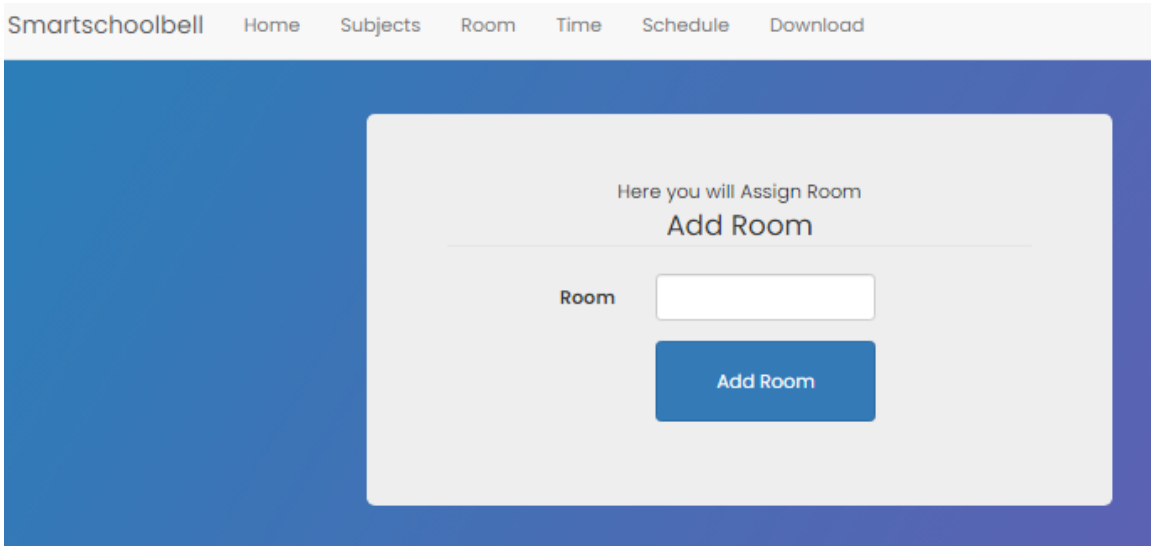


Figure 5.10 Room Activity

5.2.1.6 Time Activity

Here, as an administrator, you can manage the activity schedule for the time includes start time and end time of lecture time.

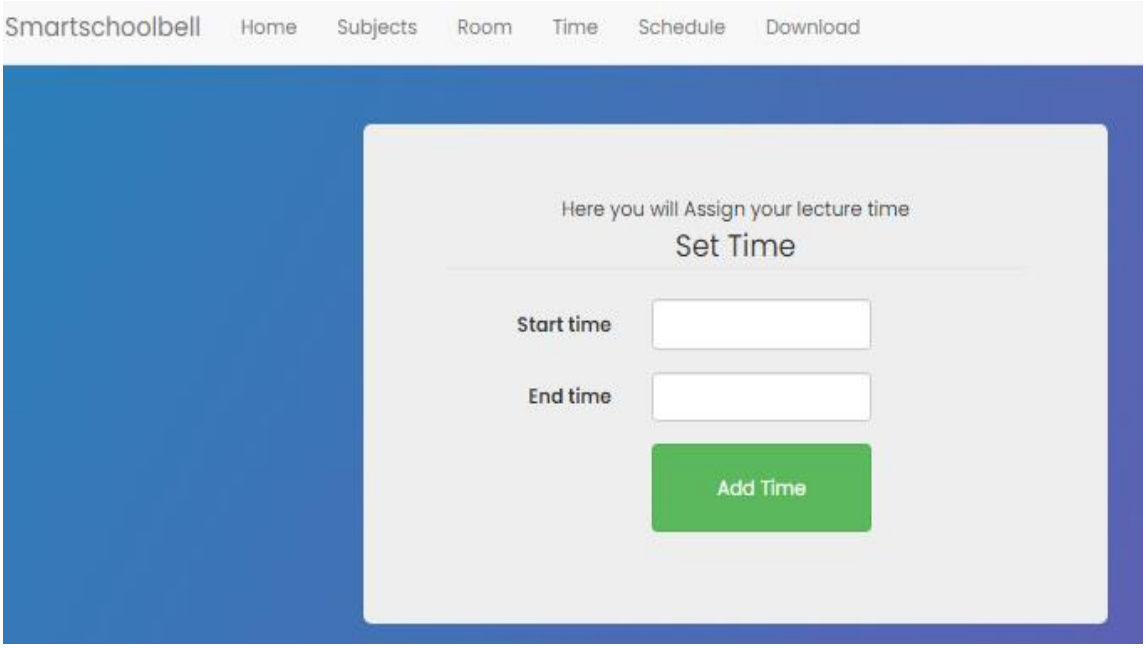


Figure 5.11 Time Activity

5.2.1.7 Schedule Activity

Here, as an administrator, you can manage overview all schedule activity for the subjects, rooms, start time and end time and specific action for modification of add or delete schedule activity.

Monday to Friday Timetable

Subject	Room	Start time	End time	Action
MATHS	R01	07:00a.m	08:30a.m	Delete
ENGLISH	R02	9:00a.m	10:00a.m	Delete
BREAKFAST	BREAK	10:00a.m	10:30a.m	Delete
HISTORY	R03	10:30a.m	11:30a.m	Delete
SCIENCE	R04	12:00p.m	01:30p.m	Delete
SECONDBREAK	BREAK2	01:30p.m	02:30p.m	Delete
CIVICS	R05	02:30p.m	03:00p.m	Delete
GEOGRAPHY	R06	03:30p.m	04:00p.m	Delete

Figure 5.12 Schedule Activity

5.2.1.8 Download Activity

Here, as administrator or headmaster or discipline master, they have to download smart school bell apk uploaded by administrator, rooms, start time and end time and specific action for modification of add or delete schedule activity.

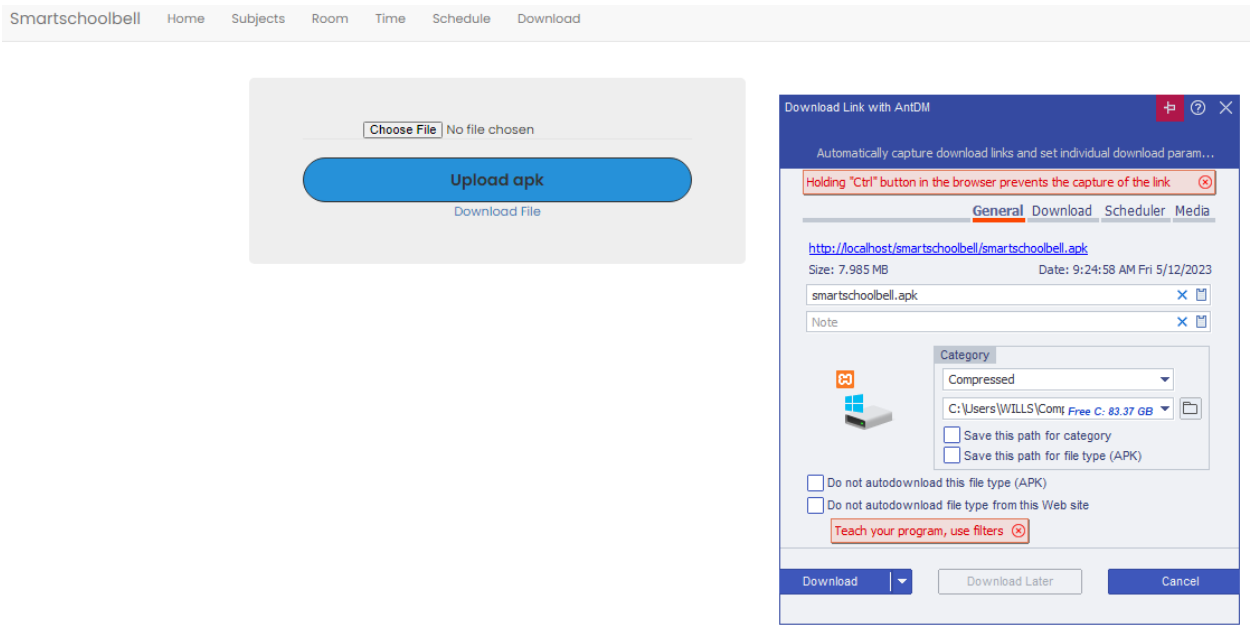


Figure 5.13 Download Activity

5.2.1.9 php local database

That's general outline of steps involved in implementing local insertion school bell information into a database using php from web portal.

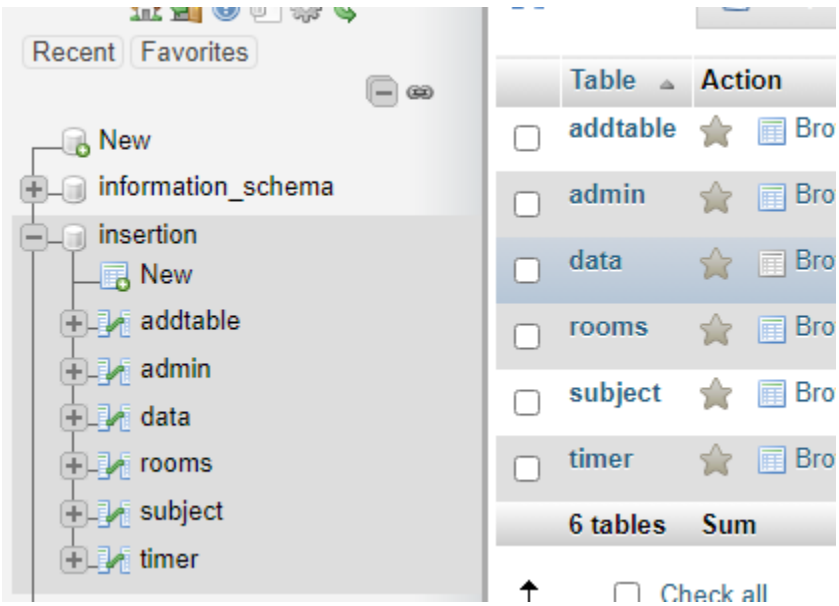


Figure 5.14 php localhost

5.2.2 Android Application

The Kodular Android application acts as an interface for teachers and staff to access timetable information and control the school bells. It provides a mobile platform for real-time updates and notifications. Teachers can view their class schedules, receive reminders for upcoming classes, and make changes if necessary. The application also enables teachers to trigger the bells manually or automatically according to the predefined timetable.

5.2.2.1 kodular android application

Here, as homepage for kodular online android application platform contains libraries, java blocks codes and screens include screen1, dashboard, signup, setting, no internet, bell timetable and home screens.

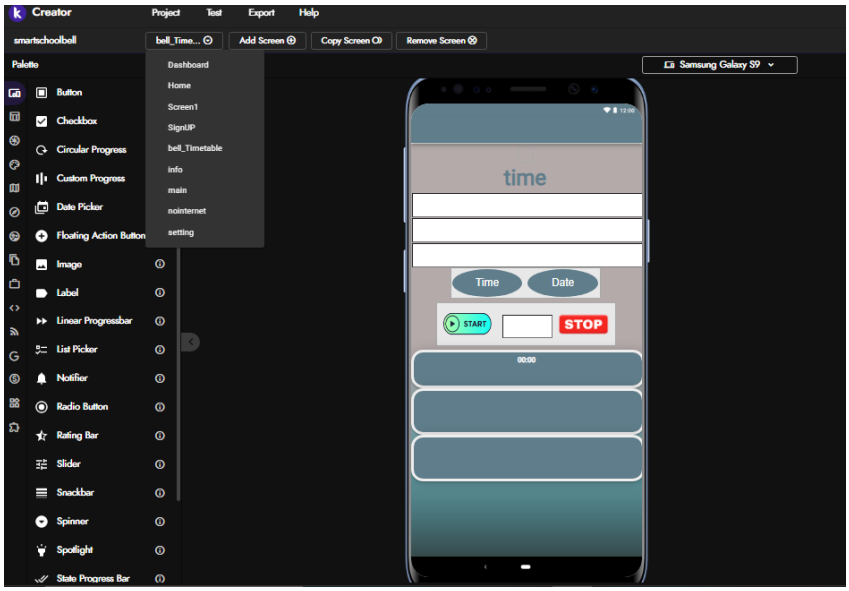


Figure 5.15 kodular android application

5.2.2.2 splash screen

Here, as visually appealing splash screen initialize page for smart school bell application with different components includes progress bars and logo as starting point.

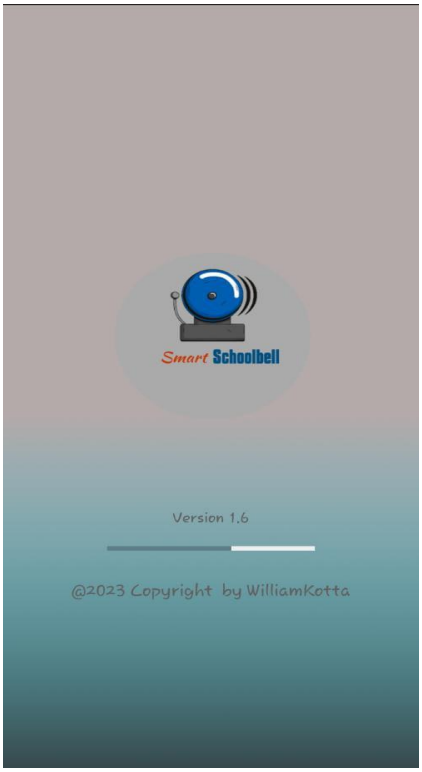


Figure 5.16 splash screen

5.2.2.3 no internet connection

Here, as visually appealing splash screen specifically for the scenario when there is no internet connection. Consider using appropriate visuals such as icons or messages indicating the absence of internet connectivity.

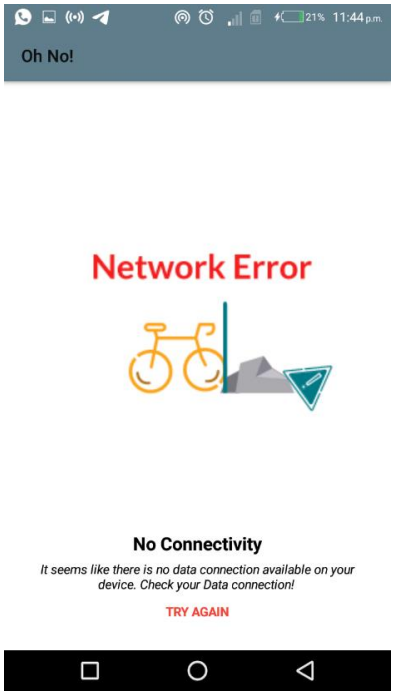


Figure 5.17 no internet connection

5.2.2.4 Signup page

Here, as layout for any other relevant registration including input fields for users to enter their username, phone number and password to be used by Headmaster or Discipline Master or School admin.

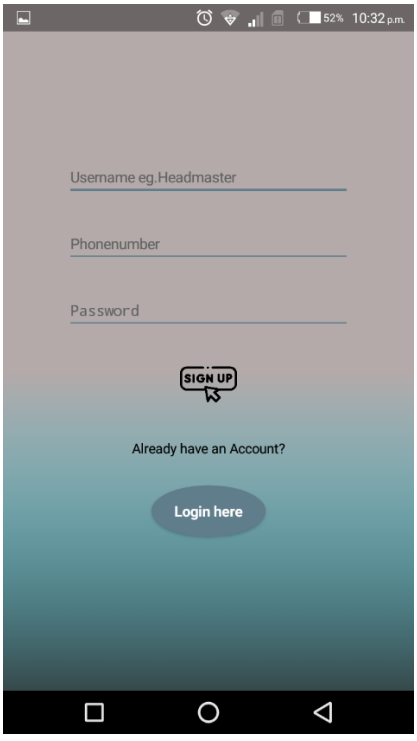


Figure 5.18 Signup page

5.2.2.5 Login page

After your account has been verified and activated, you can log in to the login page using the credentials (username and password) you created during the signup process.

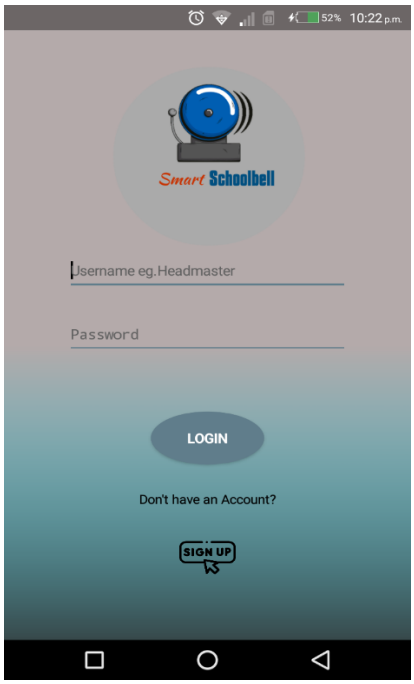


Figure 5.19 Login page

5.2.2.6 Sidebar page

Here, as navigation menu for a mobile application includes home, bell timetable, setting, information and logout navigation menu.

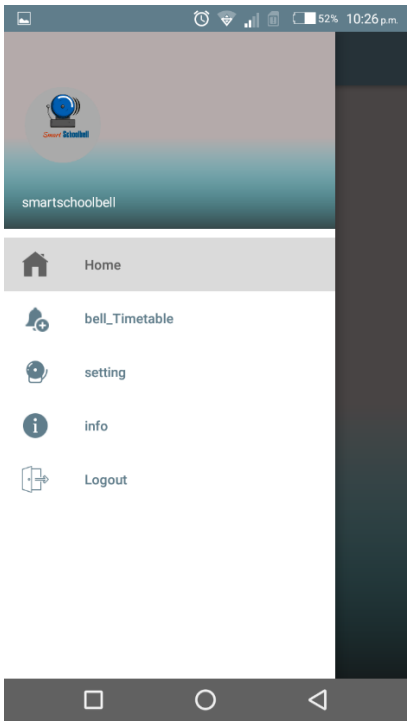


Figure 5.20 Sidebar page

5.2.2.7 Dashboard page

Here, as contain buttons refers to navigation menu for a mobile application includes home, bell timetable, setting, information and logout navigation menu. Home, this option usually takes the user back to the main page or dashboard. Bell timetable, this icon or button represents user to setup bell information includes alerts, messages, updates, or any other relevant information to be reflected to the cloud database and node mcu integration. Setting, this option reflects with web application where school administrator has to setup for whole bell schedule and so.

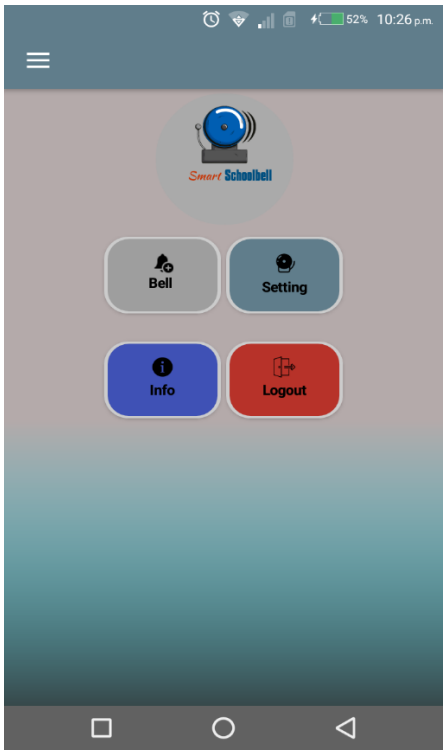


Figure 5.21 Dashboard page

5.2.2.8 Bell schedule page before set up

Here, as a section where users can view and manage the schedule for notifications or alerts. Before setting up the bell schedule, users may need to provide certain information or configure specific settings. Here's a description of the bell schedule, events, teacher name for next schedule, assigned by user example Headmaster, discipline master or school admin, picked time, picked date and sets minutes until to reach the next section.

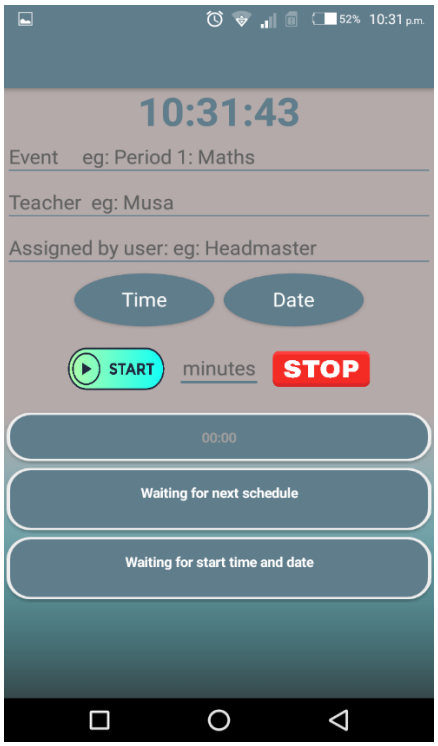


Figure 5.22 Bell schedule page before set up

5.2.2.9 Bell schedule page after set up

Here, after minutes or seconds count down to 0 secs.it displays events for instance period 1: maths and specific date and time accordingly to specific day required to schedule the school bell schedule and it integrated with firebase database and things peak together with node mcu integration through Arduino ide cloud platform and ring the circle bell through relay module and only selected event will be displayed at LCD 20X4 and other relevant information to the firebase Realtime database.

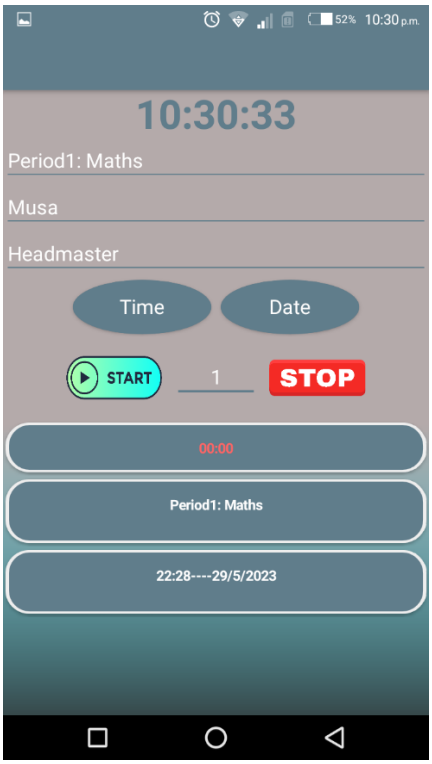


Figure 5.23 Bell schedule page after set up

5.2.3 Cloud Database (Firebase, Thing Speak through Arduino IDE)

The cloud database is a critical component of the SmartSchoolBell system, ensuring seamless data synchronization between the web portal and the Kodular Android application. Firebase, a popular real-time database, is utilized for storing and retrieving timetable data, user information, and other relevant data. Thing Speak, an IoT platform, is used to store and analyze bell scheduling and usage data for further insights and optimization by select only event to LCD 20X4 through Arduino ide or node mcu integration (Redbooks, 2014).

5.2.3.1 Firebase real time database

Here , as real time database is utilized for storing and retrieving timetable data, user information, and other relevant data includes bell schedule, school bell, and users' tables. Whereas bell schedule table retrieves information include assign by user, date, event, start time and teacher name for next schedule, also School bell tables retrieves information include bell either 1 or 0 means "on" for 1 and "off "for 0. Lastly users table for added users authorized by mobile application (Moroney, The Definitive Guide to Firebase: Build Android Apps on Google's Mobile Platform, 2017).

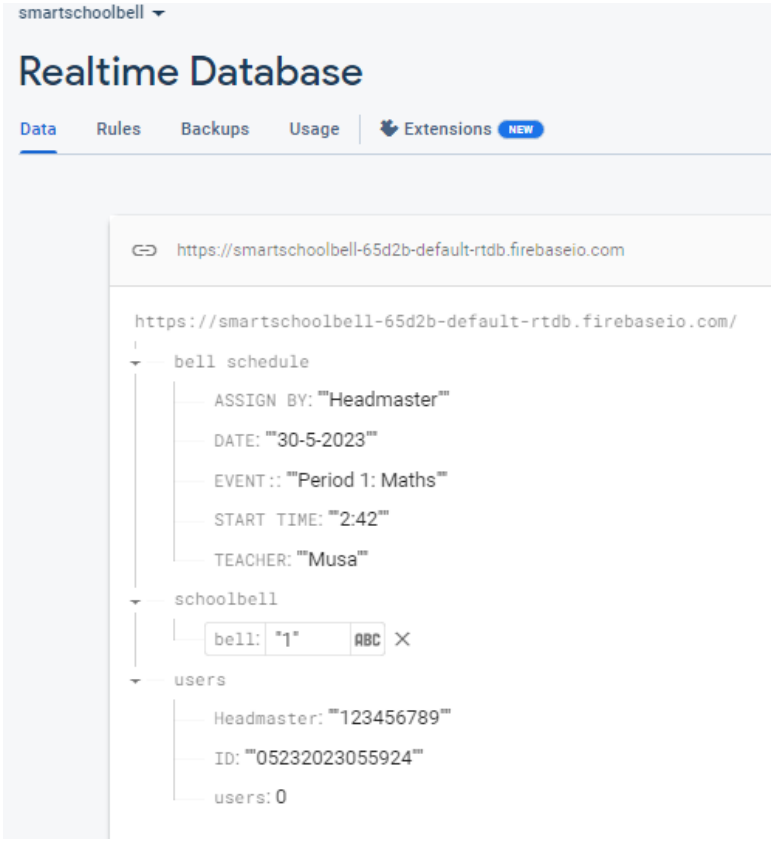
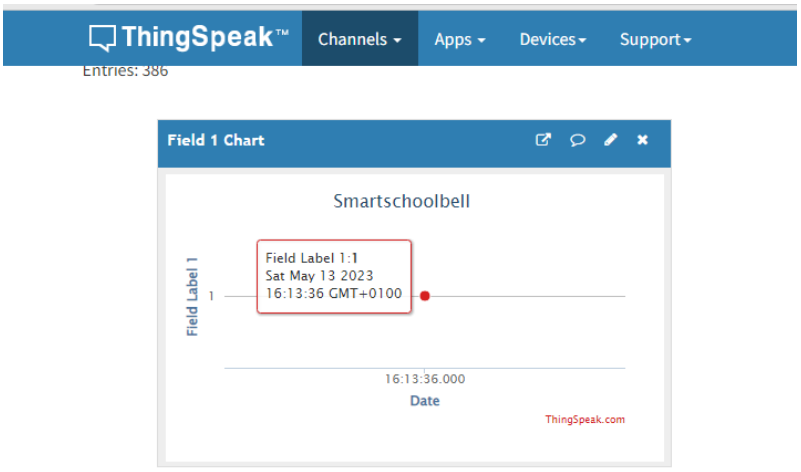


Figure 5.24 Firebase real time database

5.2.3.1 Thing speak

Here, as field visualize the only selected events to be displayed to LCD 20X4 integrated with node mcu esp 8266.Thing speak allows users to gather data from a variety of IOT devices and supports various IOT protocols, such as MQTT and RESTful APIs enable easy connectivity and data exchange between devices and platform (Paliwal, 2010).



s

Figure 5.25 thingspeak

5.2.3.2 IOT Cloud and Node mcu integration

Here, as Smart school bell with timetable display is a system that automates the ringing bells in the school to signal the start and end the class periods, breaks, and other events with timetable monitoring display. Some possible application for smart school bell includes automating the bell schedule, customizing the bell schedule, improving communication and enhancing security (gates, 1984).

Figure 5.26 IOT Cloud and Node mcu integration

5.2.3.3 Architecture connectivity

Here, as all connectivity the NodeMCU ESP8266 controls the relay module by sending a control signal to the relay module's input pin. When the appropriate condition is met (e.g., within the

specified time range on school bell timetable), the NodeMCU ESP8266 activates the relay module, which, in turn, switches on the circle bell to produce the ringing sound. The LCD 20x4 display can be connected to the NodeMCU ESP8266 via I2C or SPI interface to provide visual feedback or display relevant information (Surkar, 2014).

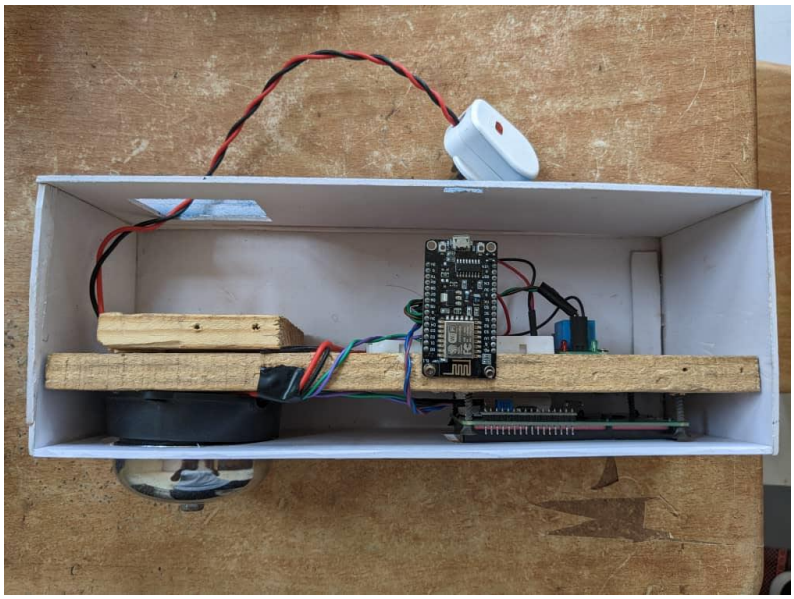


Figure 5.27 Architecture connectivity

5.3 Testing

This dissertation presents the design and implementation of a Smart School Bell system that integrates various technologies to automate the bell ringing process in educational institutions. The system utilizes the NodeMCU microcontroller, a circuit bell, a relay module, an LCD 20x4 display, Thing Speak for data logging, Firebase for real-time synchronization, and PHP for developing a web portal. Additionally, a mobile application developed using Kodular is used for testing and control purposes. Functional and user-acceptance testing was done, for functional testing; system was tested on its behavior against the functional requirements. User-acceptance was also conducted to obtain user opinion using questionnaire and interviews from few users who supported at testing the system. Results from questionnaire and interviews were analyzed with Google forms and will be presented below (R.Terrell, 2015).

5.3.1 Functional Testing

The table below summarizes testing basing on what was expected from each functional requirement **(Choudhury, 2018)**;

Table 2 Functional Testing

Functionality	Expected outcome	Test Results
i. The system should provide User Authentication: The app should allow users to create an account and log in to access the features of the app.	Academic or staffs and school admin expected to have closer communication to each other with this application	Registration and login Testing: Ensure that users can successfully register with valid inputs and that appropriate error messages are displayed for invalid inputs. Check that passwords are securely stored and cannot be easily compromised.
ii. The system should enable Event Selection: The app should allow the user to select an event from a list of available events. These events could include school periods, breaks, assembly, or any other relevant event.	System expected to have No need of Time keeper to ring the bells	The system provides notification through sound and text notifications to alert for next start time and expected next schedule.
iii. The system should enable Teacher Name Selection: The app should allow the user to select the name of the teacher who will be responsible for that event.	System expected to record of Teacher name responsible to specific schedule or subjects	The application provides Teacher Name responsible for a specific subject.
iv. The system should provide Date and Time Selection: The user should be able to select the date and time when the event starts and ends. This information will be used to set the school bell schedule.	The application expected to have date picking and time picking for record	The application allows the user to specify the date and time for when an event starts and ends. This information can then be used to set up the school bell schedule accordingly. The system should provide a user-friendly interface for selecting the desired date and time, allowing for easy navigation and input.

v. The system should provide Node MCU Integration: The app should be integrated with the Node MCU device, which will be used to control the school bell system. The app will send the selected event, teacher name, start time, and end time to the Node MCU through the IoT cloud Firebase database and Thing speak for helping to display only event to the lcd20X4.	The application expected to have real time database, IoT Cloud Platforms which expect to have closer communication between database and devices	This application allows communication with node mcu, integration with thing speak, communicate with real time synchronization with firebase. Evaluate the ease of use, clarity of instructions, and overall satisfaction of users interacting with the system.
vi. The system should enable IoT Cloud Integration: The app should integrate with the IoT cloud Firebase database to store and retrieve data. This will allow the app to communicate with the Node MCU device in order to monitor and display school schedule and ringing the school bell.	Schools expected to have access point or router to have a way of trigger the network access control to the cloud database.	The application provides all this feature and they work well.
vii. The system should provide sound notification system: The app should send notifications to the teacher's device when their event is about to start. The notifications should include the name of the event, start and end times, audio through the phone and school bell device.	Expected as reminder for announcement of special events, can be closer communication between teachers and students.	The application provides all this feature and they work well.

viii. The system should provide setting for school admin or headmaster Panel: The app should have an admin panel that allows school administrators to add and remove events, update the schedule.	Daily timetable and announcements integrated with iot cloud platform, node mcu to devices through smart actions.	Timetable from web portal have delay time 10 seconds for breakfast and 5 seconds for other periods. Mobile application announcement reached 10 seconds until to stop smart actions.
ix. The system should enable Monitoring Display: The app should trigger event to LCD 20X4 which controlled by Node MCU when action of event performed. E.g., Period 1: Maths or Breakfast. The Thing Speak platform is used to send data to the cloud, and the LCD display shows the current status of the bell and Digital clock from NTP client protocol. Finally, the mobile application is designed using Kodular Platform which act as Android studio online tool.	Staffs and students expected to have closer communication to each other with this application through monitoring display school schedules and other announcements.	The mobile application and web portal provide all these features with help of Arduino ide, iot cloud platform, firebase database and devices.

x. The system should provide Multi-Platform Compatibility: The app should be compatible with multiple platforms, including Android and iOS, to ensure that all users can access the features of the app with minimum of Increased Minimum SDK to 21 (Android 5.0: lollipop:)	Increased user accessibility: By supporting both Android and iOS platforms, the app becomes accessible to a larger audience. Android has a significant market share, while iOS is popular among users who prefer Apple devices. Supporting both platforms ensures that users on either platform can access and benefit from the app's features.	Android users can install APK files from various sources outside of the official Google Play Store. They can enable "Unknown sources" in the device settings, allowing them to download and install APK files from web portals or other app stores. iphone user can install apk file on iphone using ams1gn

5.3.2 User Acceptance testing

This testing was conducted so as to obtain user opinion on the system implemented. It was done using interviews which was guided by few questions in a questionnaire (Signh, 2018). Results were as follows;

a) The user's perception of whether or not the system will be useful.

Except for a few users who questioned whether the system would benefit those who do not have smartphones or those who have smartphones that run on platforms other than Android, everyone agreed that the system would be beneficial.

b) How users feel about the application’s security

Because membership is granted by the school, all smartphone users who took part in the interview and web portal designed, they believed the system to be secure.

c) User’s perception on whether the system is going to be helpful or not

The user acceptance testing for the smart school bell with timetable display system demonstrated its capability to meet the requirements and expectations of the end users. The system's accuracy, timely updates, user-friendly interface, accessibility, and notification system contributed to a positive user experience. Based on the UAT results, it concluded that the system is ready for deployment and use in educational institutions.

CHAPTER SIX

6.0 RESULTS AND DISCUSSION

6.1 Introduction

This chapter describes the findings of the study, goals achieved and discussion of the results. The purpose of this study is to develop a mobile application and web portal that automates the ringing bells in the school to signal the start and end the class periods, breaks, and other events with timetable monitoring display. Some possible application for smart school bell includes automating the bell schedule, customizing the bell schedule, improving communication and enhancing security (Nagao, 2019).

6.2 Findings

Findings include all results obtained from the entire process of developing the mobile application and web portal with the primary aim of automates the ringing bells in the school to signal the start and end the class periods, breaks, and other events with timetable monitoring display. In addition, the use of smart school bell with time table display can improve communication and collaboration between teachers, students and parents (Emrah, 2018).

6.2.1 Products

At the end, three products were produced: the anticipated mobile application, a web portal and a IoT devices for smartschoolbell for identifying offensive comments and replies. The products are described briefly below:

6.2.1.1 Mobile application to access timetable information and control the school bells for improving communication and enhancing security.

Android application acts as an interface for teachers and staff to access timetable information and control the school bells. It provides a mobile platform for real-time updates and notifications. Teachers can view their class schedules, receive reminders for upcoming classes, and make changes if necessary. The application also enables teachers to trigger the bells manually or automatically according to the predefined timetable. The following are the features and advantages of the android application (Kim, 2017);

i. Node MCU Integration: The app integrated with the Node MCU device, which will be used to control the school bell system. The app sends the selected event, teacher name, start

time, and end time to the Node MCU through the IoT cloud Firebase database and Thing speak for helping to display only event to the lcd20X4.

ii. IoT Cloud Integration: The app integrates with the IoT cloud Firebase database to store and retrieve data. This will allow the app to communicate with the Node MCU device in order to monitor and display school schedule and ringing the school bell.

iii. Sound notification system: The app sends notifications to the teacher's device when their event is about to start. The notifications should include the name of the event, start and end times, audio through the phone and school bell device.

iv. School admin or headmaster Panel: The app should have an admin panel that allows school administrators to add and remove events, update the schedule.

v. Monitoring Display: The app should trigger event to LCD 20X4 which controlled by Node MCU when action of event performed. E.g. Period 1: Maths or Breakfast. The Thing Speak platform is used to send data to the cloud, and the LCD display shows the current status of the bell and Digital clock from NTP client protocol. Finally, the mobile application is designed using Kodular Platform which act as Android studio online tool.

vi. The system should provide Multi-Platform Compatibility: The app should be compatible with multiple platforms, including Android and iOS, to ensure that all users can access the features of the app with minimum of Increased Minimum SDK to 21 (Android 5.0: lollipop:)

6.2.1.2 Web Portal

The web portal was created specifically for the school (administrator) in which an administrator for instance; the school master could add, update, activate and delete users. This was important for security because, with these functionalities provided exclusively for school administration, only authorized users will have access to the system (Prettyman, 2016).

i Schedule Activity

Here, as an administrator, you can manage overview all schedule activity for the subjects, rooms, start time and end time and specific action for modification of add or delete schedule activity.

ii Download Activity

Here, as administrator or headmaster or discipline master, they have to download smart school bell apk uploaded by administrator, rooms, start time and end time and specific action for modification of add or delete schedule activity.

6.2.2 Experimental findings

i. Timetable Visibility: The timetable display feature allows students and teachers to easily access the current and upcoming class schedules, reducing confusion and ensuring everyone is aware of the timetable (Statista, 2019).
ii. Flexibility and Customization: Smart school bell systems often provide flexibility in programming bell schedules. This allows schools to customize bell timings based on specific needs, such as adjusting for special events, assemblies, or changes in the regular timetable.
iii. Efficient Transition between Classes: By displaying the current timetable, students and teachers can quickly and accurately transition between classes, minimizing disruptions and maximizing instructional time.
iv. Communication and Announcements: Some smart school bell systems incorporate communication features, enabling administrators or teachers to broadcast announcements or important messages to the entire school or specific groups of individuals (Goodman, 1994).

6.3 Goals achieved

Despite several challenges, the study on the smart school bell with timetable display achieved the following goals and benefits (Nixon, 2014):

i. Enhanced time management: The smart school bell with timetable display allowed for more efficient time management in schools. It provided a clear and visual representation of the school's timetable, enabling students and teachers to be aware of their upcoming classes, breaks, and other activities. This helped in minimizing disruptions and ensuring that everyone was aware of the schedule.
ii. Improved organization: The smart school bell system helped in enhancing the overall organization of the school. By displaying the timetable prominently, it reduced confusion and provided a centralized source of information for students, teachers, and staff. This led to a smoother flow of activities throughout the day and minimized the chances of scheduling conflicts.
iii. Increased punctuality: The presence of a visible timetable display through the smart school bell system promoted punctuality among students and staff. By clearly indicating the start and end times of classes, it served as a reminder for everyone to be on time. This helped in reducing tardiness and ensuring that the educational activities commenced promptly.

iv. Minimized disruptions: The smart school bell system contributed to minimizing disruptions during class transitions. By providing audible alerts and visual reminders, it assisted in ensuring that students and staff were aware of the time remaining before the next class. This reduced noise, confusion, and interruptions during transition periods, allowing for a more focused learning environment.

v. Increased efficiency: The implementation of the smart school bell system led to improved operational efficiency. By automating the bell schedule and eliminating the need for manual bell ringing, it saved time and resources for the school administration. This efficiency gain allowed the staff to focus on other important tasks, contributing to the overall productivity of the school.

vi. Enhanced communication: The smart school bell system facilitated better communication within the school community. By displaying the timetable in a visible location, it provided a common point of reference for students, teachers, and staff. This promoted better coordination, teamwork, and collaboration among different stakeholders, ultimately benefiting the overall functioning of the school.

Despite the challenges faced during the study, the smart school bell system successfully achieved these goals, ultimately resulting in improved time management, organization, punctuality, reduced disruptions, increased efficiency, and enhanced communication within the school (Freescale Semiconductor, 2013).

CHAPTER SEVEN

7.0 SUMMARY, CONCLUSION AND RECOMMENDATION

7.1 Introduction

This chapter, explored the concept of a smart school bell with timetable display, a technology that combines traditional school bell functionality with a digital display showcasing real-time timetable information. This chapter presents a summary of the key points discussed, draws a conclusion based on the findings, and provides recommendations for the implementation and utilization of this innovative solution (Keith & Eyre, 2017).

7.2 Summary

The chapter highlighted the benefits of implementing a smart school bell with timetable display in educational institutions. We discussed how this technology automates the bell ringing process, ensuring timely start and end of classes, and eliminates the need for manual intervention. The real-time timetable display enhances communication and organization within the school, improving time management for students, teachers, and staff. We also emphasized the importance of selecting a user-friendly system and the significance of training staff members responsible for operating the technology (Bell, 2003).

7.3 Conclusion

Implementing a smart school bell with timetable display can significantly streamline the daily operations of a school. By automating the bell ringing process, it eliminates the need for manual bell activation and ensures that classes start and end on time. The timetable display feature provides real-time information to students, teachers, and staff, allowing them to stay informed about the current schedule. This promotes better time management, reduces confusion, and improves overall efficiency (Pujolle, 2006).

In conclusion, the smart school bell with timetable display is a valuable solution that significantly enhances the efficiency and organization of school operations. By automating bell ringing and providing real-time timetable information, this technology streamlines daily routines, reduces confusion, and promotes better time management. The integration of a digital display improves communication and keeps all stakeholders informed about the current schedule (Aganwal, 2010).

7.4 Recommendation and Future study:

Based on the advantages offered by a smart school bell with timetable display, it is recommended for educational institutions to consider implementing this technology. Here are some key recommendations (Steve Leibson, 2017):

1. Evaluate the specific needs and requirements of the school: Assess the school's existing bell system and timetable management processes to determine how a smart school bell solution can improve efficiency and address any pain points (Cca, 2018).

2. Choose a reliable and user-friendly system: Select a smart school bell system that is easy to install, configure, and operate. Look for a solution that offers a user-friendly interface for managing timetables and provides clear and visible displays (Elzarka, 2012).

3. Train staff and stakeholders: Provide comprehensive training to staff members who will be responsible for managing and operating the smart schoolbell system. Ensure that teachers, administrators, and other stakeholders are familiar with the features and benefits of the technology (Manyengo, 2021).

4. Regularly update and maintain the system: Keep the smart schoolbell system up to date with the latest software and firmware updates. Regularly review and adjust the timetable as needed to accommodate any schedule changes or special events (Onyema, 2019).

5. Gather feedback and make improvements: Encourage feedback from teachers, students, and staff to identify areas for improvement. Use this feedback to enhance the functionality and user experience of the smart schoolbell system (Berebanch, 2009).

By implementing a smart schoolbell with timetable display, educational institutions can streamline their operations, enhance communication, and improve time management. This technology contributes to creating a more organized and efficient learning environment for students and educators alike.

REFERENCES

Aganwal, B. (2010). Software Engineering and Testing.

Aliyu, A. B. (2017). GC-MS Analysis OF Pavetta Corymbosa Lipophilic Extract and Its . *Ife Journal of Science*, 363.

Ashton, K. (2018). Internet of things:technologies,applications,challenges and solutions.

Bell, D. (2003). UML basics: An introduction to the Unified Modeling Language. The rational edge.

Berebanch, B. (2009). A systems engineering perspective on requirements analysis.

C.Martin, R. (2018). *Clean Architecture.* A Craftsman's Guide to Software Structure and Design.

Cailong, L. (2016). Digital Technology and Application. Vol.08.

Cca. (2018). Introduction to System Analysis and Design.

Cheng, f. (2018). Build Mobile Apps with Ionic 4 and Firebase: Hybrid Mobile App Development.

Choudhury, R. S. (2018). Arduino-Based Embedded Systems: Interfacing, Simulation, and LabVIEW GUI.

Commission, I. (2014). Internet of things. *Wireless Sensor Networks*.

Davis, R. J. (2016). Raspberry Pi Lcd Projects.

Elzarka, S. (2012). Technology Use in Higher Education Instruction .

Emrah, Y. (2018). AI for Data Science: Artificial Intelligence Frameworks and Functionality for Deep Learning, Optimization, and Beyond.

Fan, Y. (2013). Computer Knowledge and Technology. P.7236-723.

Fowler, M. (2004). *UML Distilled.* Addison-Wesley Professional.

Fowler, M. (2004). *UML Distilled.A Brief Guide to the Standard Object Modeling Language.* Addison-Wesley Professional.

Fowler, M. (2014). *a definition of this new architectural term.* Microservices.

Freescale Semiconductor, I. (2013). S12 MagniV Single-Chip Mixed Signal MCU for Motor Control and CAN/LIN End-Node.

Gang, W. (2008). Electronic Component & Device Applications. P.23-24.

gates, e. &. (1984). An Introduction to Digital Techniques: Logic gates, Flip-flops, Counters and Shift registers.

Goodman, D. P. (1994). Wireless and Mobile Communications.

Hermes, D. (2019). Building Xamarin.Forms Mobile Apps Using XAML: Mobile Cross-Platform XAML and Xamarin.Forms.

II, R. J. (2016). Raspberry Pi Lcd Projects.

Institute, A. N. (2000). *Quality management systems - Requirements.*

Iversen, J. (2013). Learning Mobile App Development: A Hands-on Guide to Building Apps with iOS and Android.

Josette, M. (2017). Design and Implementation of Mobile Application for Results Dissemination System. *Journal of Software Engineering and Applications,* Vol.10 No.9.

Keith & Eyre, N. &. (2017). Bell-etal-UKERC-2017-a-smart-flexible-energy-system.

Khanna, A. (2012). smart grid controllers and home energy automation. P.165.

Kim, P. (2017). MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence.

Manyengo, P. R. (2021). Background report Digitalization in teaching and education in the United Republic of Tanzania Digitalization.

Moroney, L. (2017). The Definitive Guide to Firebase: Build Android Apps on Google's Mobile Platform.

Moroney, L. (2017). The Definitive Guide to Firebase: Build Android Apps on Google's Mobile Platform.

Moroney, L. (2017). The Definitive Guide to Firebase: Build Android Apps on Google's Mobile Platform.

Nagao, K. (2019). Artificial Intelligence Accelerates Human Learning: Discussion Data Analytics.

Nalini Radhakrishnan, N. R. (March 2020). Automatic Bell Ringing System in A College Campus By Using IOT. *The Journal of Creative Behavior* , 2320-2882.

Nanili, R. (2020). Automatic Bell Ringing System in a College Campus by using IOT. *The Journal of creative behavour*, 2320-2882.

Nise, N. S. (2014). Control Systems Engineering 7th Ed - Nise.

Nixon, R. (2014). Learning PHP, MySQL, JavaScript, CSS & HTML5: A Step-by-Step Guide to Creating Dynamic Websites.

Norris, D. (2015). The internet of things:Do it yourself at home projects for Arduino,Raspberry PI and BeagleBone Black.

Onyema, E. M. (2019). Online Discussion Forum as a Tool for Interactive Learning and Communication. *International Journal of Recent Technology and Engineering,*, 4852–4859.

Ouedraogo, K. (2022). Feasibility of Low Cost Energy Management System Using Embedded Optimization for Pv and Battery Storage Assisted Residential Buildings. *SSRN Electronic Journal*.

Paliwal, G. (2010). What is Cloud Computing Cloud computing.

Paradkar, S. (2017). Mastering Non functional Requirements.

Prettyman, S. (2016). Learn PHP 7: Object Oriented Modular Programming using HTML5, CSS3, JavaScript, XML, JSON, and MySQL.

Pujolle, G. (2006). Mobile and Wireless Communication Networks: IFIP 19th World Computer Congress, TC-6, 8th IFIP IEEE.

R.Terrell, S. (2015). Writing a Proposal for Your Dissertation: Guidelines and Examples.

Redbooks. (2014). Responsive Mobile User Experience Using MQTT - IBM Redbooks.

S. McConnell. (1998.). *Software Requirements.* Microsoft Press.

Signh, D. T. (2018). Metasploit Penetration Testing Cookbook: Evade antiviruses, bypass firewalls, and exploit complex environments with the most widely used penetration testing framework.

SmartBear. (2019). Software Testing Methodologies.

Sons, J. W. (n.d.). Scenarios, Stories, Use Cases: Through the Systems Development Life-Cycle.

Spagnuolo, G. (2022.). A Review of the Optimization and Control Techniques in the Presence of Uncertainties for the Energy Management of Microgrids. *Energies*, vol.15, no.23, pp.9114.

Statista. (2019). Market share of mobile device vendors in Tanzania from January 2015 to December 2018*. Retrieved from Statista.

Steve Leibson, X. D. (2017). Digital System Design with FPGA: Implementation Using Verilog and VHDL.

Surkar, S. K. (2014). Foundation of Digital Electronics and Logic Design.

Toosi, H. E. (2021). Dual-layer power scheduling strategy for EV-ESS-controllable load in bi-directional dynamic markets for low-cost implementation. *International Transactions on Electrical Energy Systems*, vol.31, no.1.

Wang, H. &. (2013). What Affects Mobile Application Use? *International Journal of Markerting Studies* , 2.

Wiegers, K. E. (2003). Software requirements: practical techniques for gathering and managing requirements throughout.

Winslow, J. &. (2012). mobile technologies. *Tools for Organizational Learning and Management in Schools.*, 8.

Xiao, P. (2018). Designing Embedded Systems and the Internet of Things (IoT) with the ARM® Mbed™.

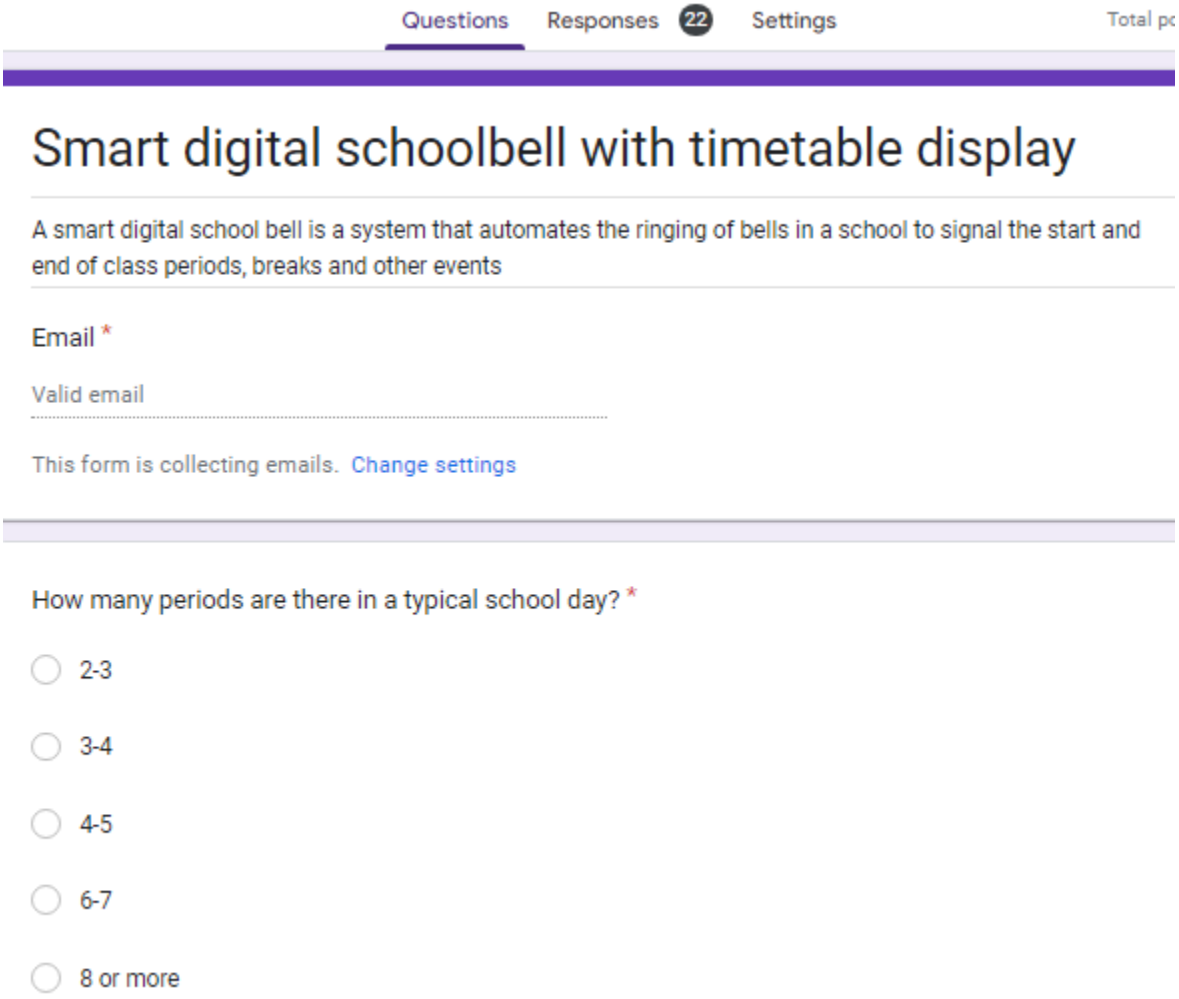
Yuan, X. &. (2012). A research on secure smart home based on the internet of things. *IEEE International Conference on Information Science and Technology*, P.737-740.

Zanella, A. (2014). Internet of things for smart cities . *IEEE internet Things*, 22-32.

Zehra, R. B. (2016). Perceptions of Teachers Regarding Technology Integration in classrooms. *Journal of Education and Educational Development*.

APPENDICES

Appendix: Research Questionnaire for Teachers, Students and Parents



How long is each period? *

- 30 minutes
- 45 minutes
- 60 minutes
- 75 minutes or more

Is there a set schedule for the schoolbell or does it vary day to day? *

- Set schedule
- Varies day to day

Are there any breaks between periods ? *

- No breaks
- Short breaks (5-10 minutes)
- Long breaks (15-20 minutes)
- Other...

Is there a warming bell before the end of each period ? *

- Yes
- No
- Other...

Are there any special events schedules for exams or final periods? *

- ○ Yes
- ○ No
- ○ Other...

Are there any special schedules for half days or early release days? *

- ○ yes
- ○ No
- ○ Other...