Strathmore University

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A low cost automatic cooking oil vending machine for small scale traders

By

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Strathmore University

2024

Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

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Date…26 March 2024…….

Dedication

I dedicate this project firstly, to God for giving me the strength and wisdom.

Secondly, I dedicate it to Victoria Koi, my mother, for being a true source of inspiration, motivation and for funding my Masters' degree studies. I would also not be here if it were not for the never ending cheers from my siblings; Linda, Joan and Priscilla Koi.

Thirdly, I dedicate this project to my husband Jeremy Yongo for holding my hand through the years of pursuing this Masters' degree.

Lastly, I dedicate this project to my project supervisor Dr. Vitalis Gavole Ozianyi for believing in me.

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Finally, I give my gratitude to my family, friends and colleagues who assisted me throughout my dissertation.

Abstract

People are always looking for convenience in handling commodities and other basic needs in life and vending machines have played a vital role in making human life easier. However, due to the nature and design of vending machines, they are either too expensive or too large to meet a small-scale trader's needs. Most small-scale sellers have limited resources and small spaces for operation, introducing the vending machines present in the market would be very costly and will occupy a lot of space leaving them with limited or no space to operate in. Therefore, small-scale traders remain comfortable with the old ways of manually measuring liquids, in this case the cooking oil, as the new technology in liquid dispensing does not cater to their needs.

In this study, a low cost automatic cooking oil vending machine that allows the desired amount of oil to be dispensed was fabricated. Though there are some earlier versions of these machines available, this study focused on providing a low cost, simple design that could be easily accessed by small scale traders. This enables easy and accurate measurement in the selling of cooking oil eliminated physical measuring. It is a cheap and efficient way of selling cooking oil, simple and specific to a local seller.

The main objective of the study was to develop a low cost automatic cooking oil vending machine for small scale traders. This encompassed looking into existing technologies used by automatic vending machines and the limitations of the current vending machines for small scale traders. The researcher went ahead to design, develop and test the cooking oil vending machine for small scale traders.

The study employed a descriptive research design. The various identified features formed the basis for crafting the system tests for the final developed system. An Agile Software development methodology was also employed and the system underwent four main phases: Designing, Development, Testing and Deployment.

Key Words: Arduino-Uno microcontroller, Small scale traders, Vending machines, Cooking oil.

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Chapter One: Introduction

1.1 Background of the Study

A vending machine is an automated machine that provides items such as snacks, beverages, alcohol, cigarettes and lottery tickets to consumers after money or a credit card is inserted into the machine (Kumar, 2018). According to Higuchi (2007), the first vending machine is thought to have been introduced at a temple in Alexandria in 215 BC. The machine dispensed holy water in return for a small coin. The oldest extant machines are cigarette-vending devices that were installed in English pubs and hostels as early as 1615.

By the 1900s, other manufacturers saw the possibilities of putting their products in these machines, and they started taking over modern institutions in addition to the streets. The machines were then used to sell handkerchiefs, confections, and cigarettes. During this period, the first automats were created in America, helping in dispensing water and milk for a penny. Fast food businesses also adopted this practice with supplements such as cakes, sandwiches, and soft drinks dispensed through the machines. These developments formed the basis of modern vending machines (Segrave, 2015).

Automated vending machines for dispensing cash had dominated the vending industry in Kenya until recently, when milk ATMs gained popularity. According to Bockline Omedo Bebe (2018) a milk ATM is an automated facility that dispenses chilled, pasteurized, ready-to-drink milk that is sold unpackaged. The ATM offers several advantages. For the business, they eliminate packaging and processing which lower retail prices, and automated business transactions ease monitoring of sales turnover. The popularity of these machines has grown since and are now widespread and located in various strategic outlets: retail shops, farms, cooperatives, supermarkets and milk bars (Kosgey, 2018).

Kenya has integrated the use of these machines in daily activities despite having limited technology and need integration levels when compared to the developed world. According to the Pew Internet & American Life Project, even as technology becomes more affordable and internet access seems increasingly ubiquitous, a “digital divide” between rich and poor remains. The rich and educated are still more likely than others to have good access to digital resources(Liz, n.d.).

Kaguara & Wanjiru (2012), define Digital Divide as the growing gap between those who have access to and the skills to use ICT and those who, due to economic or/and geographical reasons, have limited or no access.

According to Oscar Ingasia Ayuya (2020) imported milk ATM machines cost about KES 1.2 million, while locally fabricated machines cost between KES 120,000–700,000, depending on specifications and level of compliance with food safety requirements. Besides the initial investment, ATM businesses incur other costs such as licensing, branding and maintenance. Such prices do not look appealing to small scale traders as the initial investment alone is capital intensive.

The main driver of this research was to develop a low cost automatic cooking oil vending machine for small scale traders who due to lack of capital and inaccessibility to automation technology cannot enjoy the effectiveness and efficiency of technology. This research focused on fabricating an automatic cooking oil vending machine that allowed the desired amount of oil to be dispensed. The vending machine included a holding container with the cooking oil to be dispensed which was placed on top of the machine to take advantage of gravity for dispensing, cutting out the pump to reduce cost. This was closed by a tight valve to avoid leakage; the valve was programed to dispense the amount of cooking oil required. A counter measure of a level sensor was placed in the holding compartment to ensure proper measurement. After measurement, the customer was allowed to dispense the cooking oil into their container.

1.2 Problem Statement

Liquids are a big part of the products that people consume, to list a few from water, which is an indispensable resource, milk, cooking oil, kerosene, lotion. All these products are sold in quantified packages, which makes the transaction process simple. Custom liquid volume products are gaining popularity in the business sector, however measurements at the point of sale poses a huge challenge for most businesses (Pfister, 2011).

Retailers tend to buy such products for example cooking oil, in large scale because it is cheaper thus more profits, the trick is in buying and producing in large scale then selling in smaller quantities. Given this situation, the traders settle for physical measurement at the point of sale, leaving room for inaccurate measurement and is time consuming. Liquid vending machines

already exist in the market, but they are either too big or too expensive. Most do not meet the needs of a small scale seller. Therefore, this seller remains comfortable with the old ways of measuring liquid, as the new technology in liquid dispensing does not cater to their needs.

1.3 Study Objectives

1.3.1 Main Objective

The main objective of this study was to develop a low cost automatic cooking oil vending machine for small scale traders

1.3.2 Specific Objectives

1. To evaluate the existing technologies used by automatic vending machines.
2. To review the limitations of the current vending machines for small scale traders.
3. To design and develop a low cost automatic cooking oil vending machine for small scale traders.
4. To test and validate a low cost automatic cooking oil vending machine for small scale traders.

1.4 Research Questions

1. What are the existing technologies used by automatic vending machines?
2. What is the limitation of the current vending machines for small scale traders?
3. How will a low cost automatic cooking oil vending machine for small scale traders be designed and developed?
4. How will a low cost automatic cooking oil vending machine for small scale traders be tested and validated?

1.5 Project Justification

In Kenya, different types of liquid vending machines are imported from Italy, China, and The Netherlands. There are also locally fabricated machines, which copy the design and specifications of imported machines. The imported machines, such as milk dispensing A.T.M.s, are estimated to cost at least 1.2 million Kenya shillings (Ayuya et al. 2020). These machines vary in capacity and pricing with an average of Ksh 150,000 to 700,000, as determined by Bebe,

van der Lee, and Kilelu (2018) as the cost for locally fabricated ones. These machines are also estimated to have an annual operational fee of Ksh 123,200 with the majority of these costs spent in servicing the machines. These costs reduce the profits of traders whose sales also vary depending on competition and location. The high servicing costs can also result in reduced incentives for traders. Reducing the cost of running the vending machines by reducing human resources is, therefore, an ideal strategy for cost-efficiency. (Ayuya et al. 2020)

This study sought to provide small scale traders with an effective and efficient way of selling their liquid products. The study enhanced the ease and accuracy of liquid selling by incorporating the automatic measuring and dispensing system. This is not only enhanced the user experience but also reduced the human assistance to the use of the machine.

1.6 Scope of the Study and Limitations

The study focused on automating the liquid dispensing system using an Arduino microcontroller. The current rates of technological adaptation in Kenya are growing at a faster pace, but most people are still not conversant with the utilization of such systems. The research assumed that most traders and users are conversant with this type of technology and can learn or employ a third party with the needed skills.

Chapter Two: Literature Review

2.1 Introduction

This chapter presented a detailed overview of the different types of technology used by vending machines. The study reviewed the major limitation of the current vending machine for small scale traders. Finally, a conceptual model of the proposed low cost automatic vending machine was discussed.

2.2 Existing technologies for automatic vending machines

According to Ratnasri & Sharmilan, (2021), there were lots of vending machines developed by several research groups such as PLC based change dispensing machine, PLC based automation of multiple fluid vending machines, AVR ATmega8515 based liquid dispensing vending machine, Arduino based reversed vending machine, Finite State Machine based vending machine with auto-billing features, RFID based ration vending machine, and touchscreen-based medical vending machines. Some of these technologies are discussed in this chapter.

2.2.1 PLC based vending machine

A Programmable Logic Controller, PLC is a digital computer used for automation. It is an interface between the program and the inputs. It is a programmable software which works depending on the inputs given and their state, turning on/off its outputs. (Baladhandabany et al., 2015).According to Anubhaw; & Rani, (2016), the input/output (I/O) system is physically connected to the field devices that are encountered in the machine or that are used in the process control. The I/O interfaces provide the connection between the CPU with the information providers (inputs) and controllable devices (outputs). During its operation, the CPU completes three processes: (1) it reads, or accepts, the input data from the field devices via the input interfaces, (2) it executes, or performs, the control program stored in the memory system, and (3) it writes, or updates, the output devices via the output interfaces. This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning.

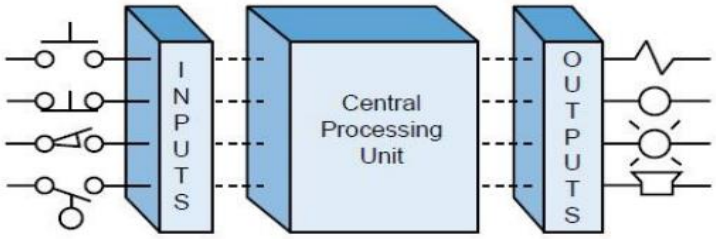


Figure 2:1 Basic PLC Operation Process

PLC works by a programmable support with some criteria. The PLC is connected with some components and it is made to run with the help of program (Baladhandabany et al., 2015). According to Badgujar, (2017), the programming software for this PLC is Siemens of the version 7. In Siemens model of PLC, there are total 11 inputs and 8 outputs. Siemens communication channel allows for simple connectivity to a personal computer for program upload, download and monitoring using multiple protocols.

2.2.2 Multiple fluid vending machine for offices and restaurant

According to Badgujar, (2017), multiple fluid vending machines for office and restaurant use simple vending machine which has multiple outputs. These systems contain PLC unit, solenoid valves, color sensors and position sensors. Inputs for the machines are high level sensors, low level sensors, cup position sensors and color sensors. Output of the systems are solenoid valves and motors.

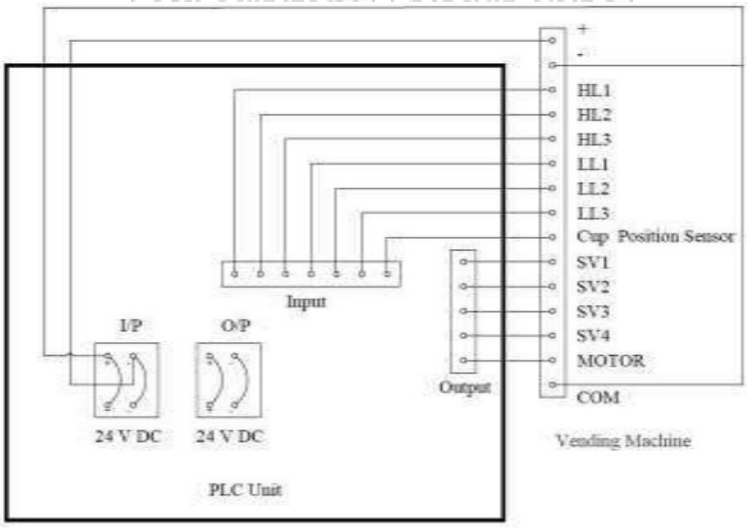


Figure 2:2: Block diagram of multiple fluid vending machine

PLC executes the program by one instruction at a time. Hence it already knows which inputs is on/off, from the previous process. PLC then updates the status of the outputs (Baladhandabany et al., 2015).

2.2.3 Arduino UNO based vending machine

According to Wong et al., (2019), Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online.

Arduino uses hardware known as the Arduino development board. Arduino software for developing the code is known as the Arduino IDE (Integrated Development Environment), these microcontrollers can be programmed easily using the C or C++ language in the Arduino IDE (Ismailov & Jo‘rayev, 2022).

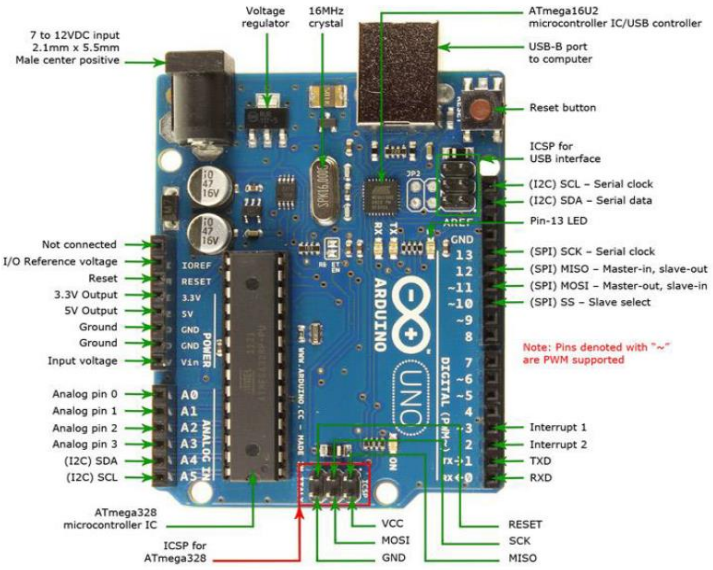


Figure 2:3 A labeled diagram of an Arduino Board and an IDE

2.2.4 Automatic Chocolate Vending Machine Using Arduino Uno

This is an Arduino based vending machine that sells different types of chocolates from a machine. There are three parts; First part is scanning of RFID card which provides cashless payment. The second is the programming unit which is implemented using Arduino. The third part is display of information and delivery of the product at the output. The Arduino acts as main

processor and the vending machine containing an Arduino Uno as a master controller along with RFID tag and reader. There are various slots on Arduino Uno for connecting various external devices such as keypad and display. First, the RFID card is scanned and after reading the RFID the user can select the product as per the choices. This is done with Arduino software. Then the product is inserted in spiral spring, which is connected to stepper motor, the motor driver circuits are interfaced between Arduino and stepper motor. The motor rotates at a fixed angle and dispenses the product to the user at the output of vending machine. (Desai *et al.*, 2017).

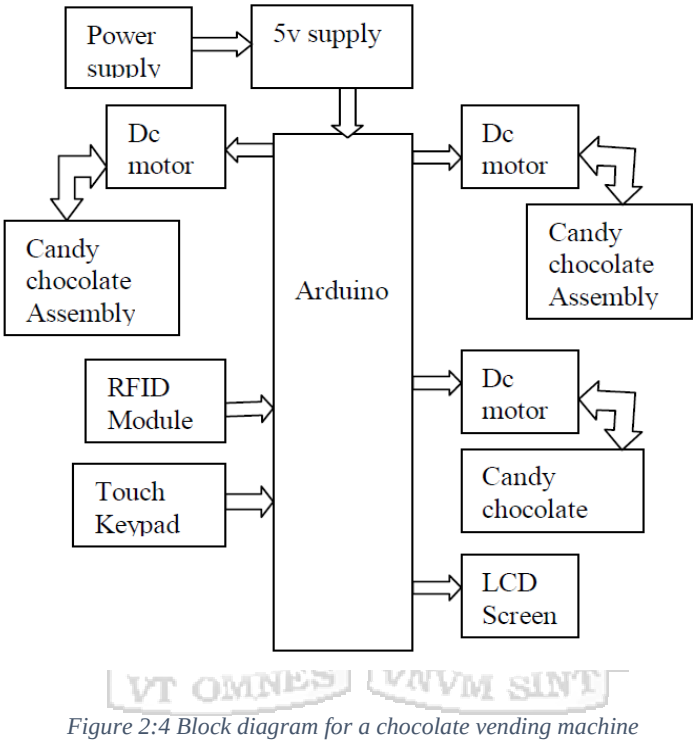


Figure 2:4 Block diagram for a chocolate vending machine

2.3 Limitation of the current vending machines for small scale traders

Liquid dispensers are not new in the world of machinery and automation. However, this technology does not cater for the small scale traders. Small scale traders run a small retail shop that serves the immediate community. Their income is not a lot and the space at the shop has limited space. Therefore, large and expensive vending machines are not appealing to them.

2.3.1 Prohibitive High Cost.

According to Bebe Omedo et al., (2018), different types of milk ATM models are in the market; some are imported from China, Italy and The Netherlands. They vary in capacity and price, ranging from KES 150,000 to 700,000 (USD 1,500–7,000). The alternative is leasing a vending machine which typically involves a monthly fee of around $50 per month and ranges upwards of $150. Their average annual operational costs, based on information collected from sampled operators, amount to KES 123,200 (USD 1,232).

A vending machine has a fixed cost to set up, maintain, repair, and manage. A vending machine requires proper care. One must maintain and repair it timely to avoid any technical failure. This becomes challenging as repair and maintenance charges are high as well as requires a technical expert on time. (Vendify, 2020).

One is also required to pay taxes on the money you make from the machine, which will need an employee to spend more time gathering and organizing sales data. (Roberti, 2022). Just like any other business, vending machine businesses are responsible for paying taxes. In most cases, you will have to obtain a tax license and decal stickers for your machine. Depending on the area you operate in, you may be subject to additional state and/or county taxes on the revenue generated by the machine (Franchise Direct, 2021). Heavy taxes levied on the location sites of these machines adds another straw to this capital-intensive investment (Ratnasri & Sharmilan, 2021).

As the world industries continue evolving, the problem is that the electricity usage of smart vending machine has not yet been benefitted from this revolution whereby the machine will always be on even whether there is transaction or not. There has not been any Artificial Intelligence (AI)-powered vending machine for the electricity usage. If this idea is made into reality, the AI could unleash the full potential of electricity usage in the vending machine.(Abdulla et al., 2022)

2.4 Conceptual Framework

The vending machine includes a holding container with the cooking oil to be dispensed which is placed on top of the machine to take advantage of gravity for dispensing, cutting out the pump to reduce cost. This is closed by a tight valve to avoid leakage; the valve is programmable to dispense the amount of cooking oil required. A counter measure of a level sensor is placed in the holding compartment to ensure proper measurement. After measurement, the customer is allowed to dispense the cooking oil into their container.

The figure 2:5 below represents the proposed system.

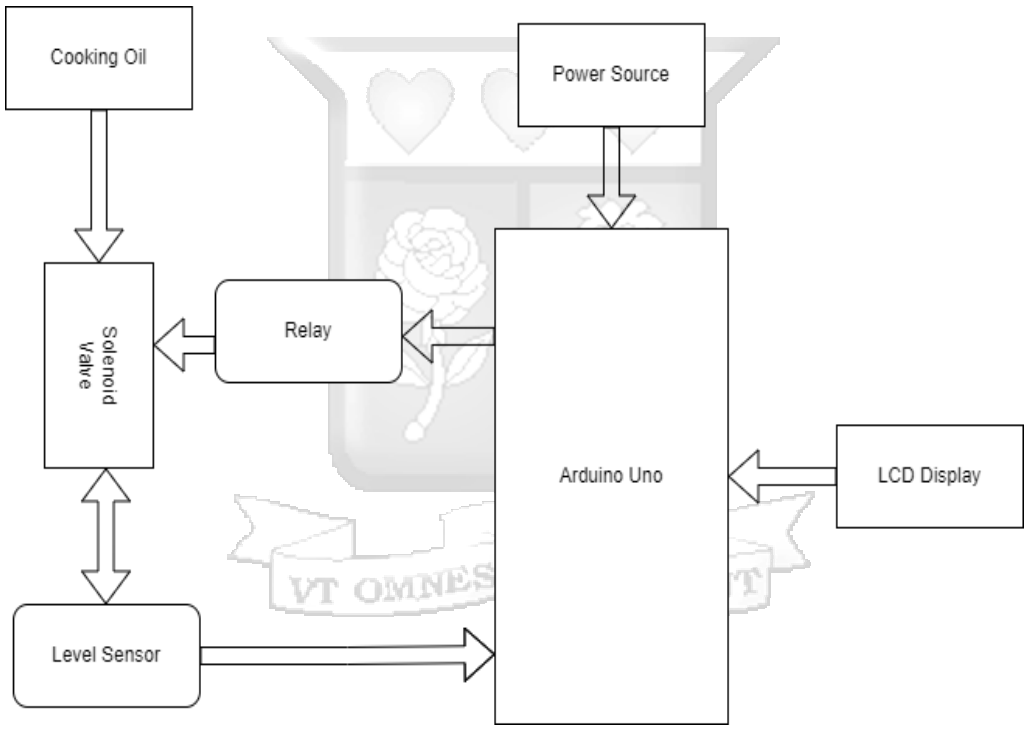


Figure 2:5 Conceptual Diagram

2.4.1 Key Elements

LCD

A Liquid Crystal Display (LCD) displays the data received from Arduino board.

Solenoid Valve

A solenoid valve is used to control the flow of liquid.

Arduino Uno

The Arduino Uno act as a microcontroller and it controls the whole process.

Chapter Three: Research Methodology

3.1 Introduction

This chapter focused on the Software Development Methodology used to design the liquid dispenser system. It then discussed the research methodology to be used in carrying out the research. Finally, the research quality aspects are discussed.

3.2 Research Design

Research design is a guide for research study defining the type of study, data collection, and analysis. This helps the researcher to obtain the relevant evidence by outlining the type of evidence needed to answer the research questions (Krogh, Markussen, and Bang, 2015).

The study employed a descriptive research design. The various identified features formed the basis for crafting the system tests for the final developed system.

3.3 Software Development Methodology

The study employed Agile Software development methodology. The proposed system underwent four main phases as discussed in the subsequent sections.

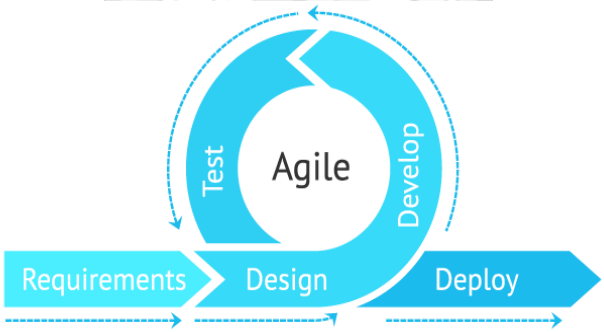


Figure 3:1 Agile Software Methodology

Agile Software Development is built on the premise that software development is inherently uncertain and that changes should be expected. (Munassar & Govardhan, 2010)

The dispenser system was fully designed, developed and tested within the stipulated academic time. Agile approach was adopted where the system was developed in iterations, each adding a specific requirement to the system. This was accommodated by the agile approach.

3.3.1 System Requirements

In this phase, the researcher sought to know the various functional and non-functional requirements of the system. A thorough review of existing literature on the system structure was conducted to help create a solution to the existing problem that small scale traders face.

3.3.2 System Design

A Data Flow Diagram (DFD) was used to show a graphical contextual design of the system. This aided in clarifying any external systems interacting with the system. Object oriented analysis was adopted to help identify and model all objects interacting with the system. Use Case diagrams and use case descriptions was put to use to model each object's interaction with the system. Finally, an Entity Relationship Diagram (ERD) was used to graphically conceptualize the relationships between the identified objects. The ERD was also used to model the system's database.

3.3.3 System Development

The study aim of the study was to come up with a cooking oil vending machine for small scale traders.

A container of about 10 liters that will hold the cooking oil to be dispensed was placed on top of the machine to take advantage of gravity for dispensing, thus eliminating the pump in the project. The container was closed by a solenoid valve which dispenses the amount of cooking oil required. The sensor was used to measure the flow rate of the cooking oil and calculate the needed amount of fluid. The researcher wrote an Arduino program which bears different instructions to ensure the system operates as required.

3.3.4 System Testing

Once development of each module was completed, testing was done on it. This was done to ensure the application meets the functional needs. To test the prototype functionalities and its user acceptance, various types of tests were conducted.

3.4 Ethical Measures

Research quality, by definition, refers to the extent to which a research was carried out properly (NCDDR, 2005). In this study, research quality was assessed based on the validity and reliability of the research.

3.4.1 Reliability

Reliability is defined as the extent to which the outcomes of a research can be replicated, given the same conditions and approach (Kinako, 2016).The principle idea of reliability is that the

parameters of the population under study are stable or constant and should produce the same (or nearly the same) results if the same individuals and conditions are used. Once the proposed system was finalized, the researcher conducted full testing to ascertain the validity of the proposed application in order to confirm whether the application introduces efficiency into the cooking oil dispensing process. Such validity checks ensures that the study can be replicated to produce a similar application in any future studies.

3.4.2 Validity

Kinako (2016), defines validity as the extent to which a study's results truthfully and accurately reflect the intended objectives. In order to ascertain internal validity, the researcher conducted a preliminary review of only the very recent literature and systems on the topic at hand. This preliminary review ensured that the system implemented was developed in a way that can be integrated with the current systems.

3.5 Summary

This chapter has described the various phases the proposed system will undergo. A description of the tools employed in each of the phases was discussed in detail showing how each tool was used. A justification of the agile methodology was offered as well as the research design employed. This chapter and the one proceeding therefore sought to answer the final research question by developing and testing a low cost automatic cooking oil vending machine and validating its effectiveness.

3.6 Research Budget

Below was the proposed budget to conduct this study.

Item	Description	Quantity	Rate	Amount
1	Microcontroller	1	1600	1600
2	Solenoid valve	1	1500	1500
5	Level Sensor	1	1000	1000
6	Plastic food based containers	1	500	500
7	Power Source	1	1000	1000
8	Jumper wires	Numerous	100/= per pack	200
9	Power elements	Numerous	-	200
TOTAL				**6,000**

Chapter Four: System Analysis, Design and Architecture

4.1 Introduction

This chapter elaborated the system design and architecture of the proposed solution as derived from various data sources. It also encompassed the presentation of use case diagrams, sequence diagrams, entity relationship diagram and wireframes.

4.2 System Analysis

4.2.1 Functional Requirements

i) The vending machine was able to turn on and display system menu

ii) The vending machine recognized the asterisk button as the instruction to start an order

iii) The vending machine recognized the hash button as the instruction to check the available amount of cooking oil in the vending machine

iv) The vending machine displayed an error in case there was insufficient amount of cooking oil in the vending machine

v) The vending machine dispensed the accurate amount of cooking oil as instructed by the user

4.2.2 Non-Functional Requirements

This refers to attributes that affect user experience when interacting with the system, these characteristics include:

i) System availability – the vending machine was available all the time.

ii) Reliability – the system is dependable.

iii) Usability – the system had an easy to navigate user interface and should be user friendly.

iv) Integrity – the system dispensed the specified amounts of cooking oil.

4.3 System Design

System design comprised of creating a layout of the system or application design that was developed, object-oriented techniques was used to transform the conceptual framework or model in object-oriented analysis considering the constraints imposed by the chosen architecture and any non-functional. The concept from the analysis was mapped onto implementation classes and interfaces.

4.4 System Architecture

4.4.1 Use case Diagram and Descriptions

Figure 4.1 shows the use case diagram that shows the interaction that the users have in the system. The actors have been identified as the customer and vendor.

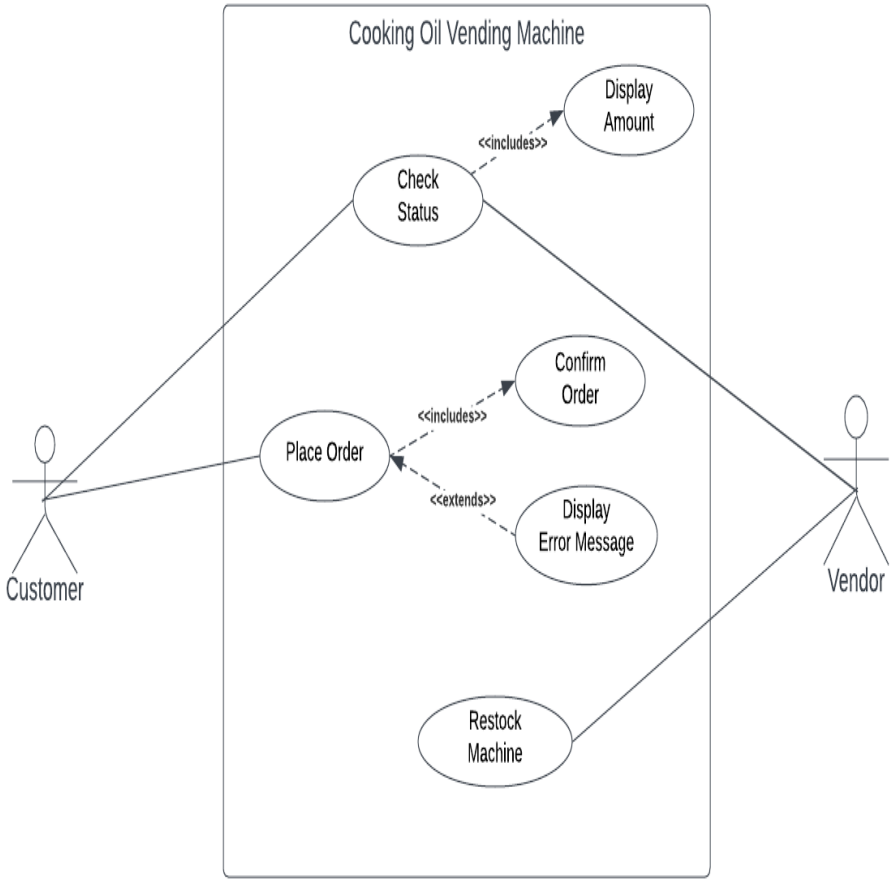


Figure 4:1 Use Case Diagram

Use Case Descriptions

Use case description is seen in the subsequent tables. This shows how the users perform the tasks as they interact with the application.

Table 4.1 Check Status Use Case Description

Use Case 1	**Check Status**
Description:	Describes how the Customer or Vendor will view the amount of cooking oil available in the vending machine
Primary Actors	Customer and Vendor
Precondition:	The customer must switch on the vending machine and select the check status option
Post condition:	The vending machine must display the amount of cooking oil available
Typical case of Events **Actors Response** 1. Turn on the Vending Machine 2. Select check status option	**System Response** 1. Display welcome message and menu 2. Display available amount of cooking oil in the machine
Alternative Flow Request not submitted	

Table 4.2 Place Order Use Case Description

Use Case 2	**Place Order**
Description:	Describes how the Customer can make an order from the vending machine
Primary Actors	Customer
Precondition:	The customer must key in the amount of cooking oil they want to purchase
Post condition:	The vending machine confirms the order and dispenses the

	requested amount
Typical case of Events **Actors Response** 1. Keys in the amount of cooking oil to purchase. 2. Places container at the tap	**System Response** 1. Display confirmed order message. 2. Dispenses cooking oil to the customer's container
Alternative Flow Display error message	

Table 4.3 Restock Machine Use Case Description

Use Case 3	**Restock Machine**
Description:	Describes how the Vendor refills the vending machine once the cooking oil level is low
Primary Actors	Vendor
Precondition:	The vendor must check status of the vending machine
Post condition:	Vending machine must display the amount of cooking oil available
Typical case of Events **Actors Response** 1. Select check status option. 2. Refills the amount of cooking oil required	**System Response** 1. Display available amount of cooking oil in the machine
Alternative Flow Displays quantity of cooking oil required to operate	

4.4.2 Sequence Diagram

Figure 4.2 shows the sequence diagram which illustrates the interaction of the users with the system. Once the vending machine is installed, the users can interact with the system. The sequence diagram shows the event that take place and the feedback response obtained from the system to the user.

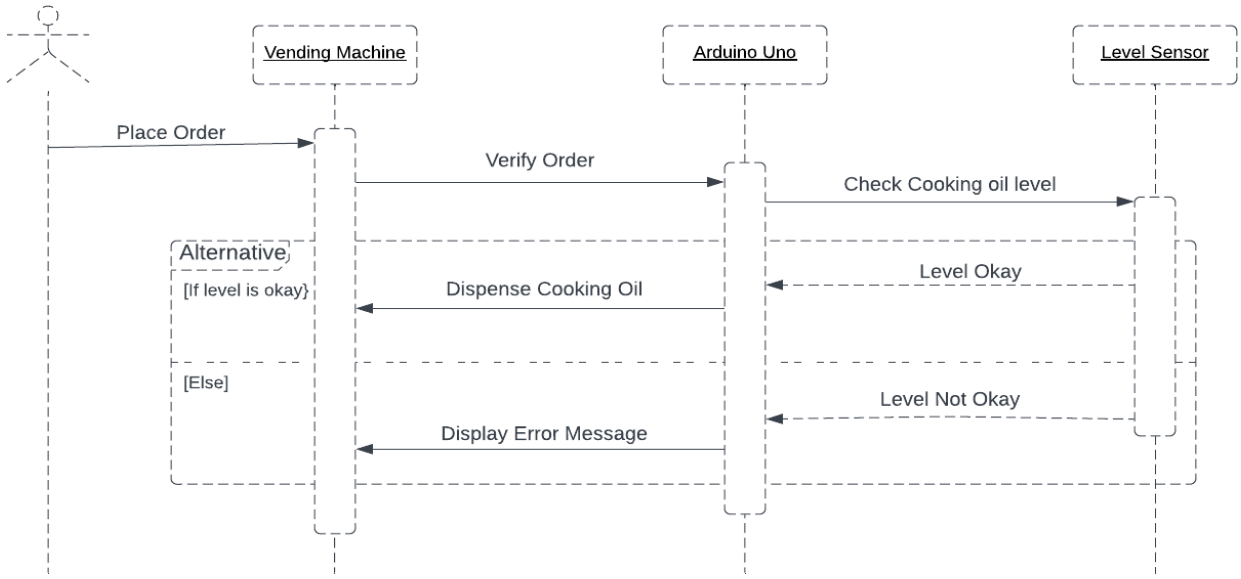


Figure 4:2 Sequence Diagram

4.4.3 Entity Relationship Diagram

Figure 4.3 demonstrates the conceptual view of the systems database as well as how the tables relate to each other.

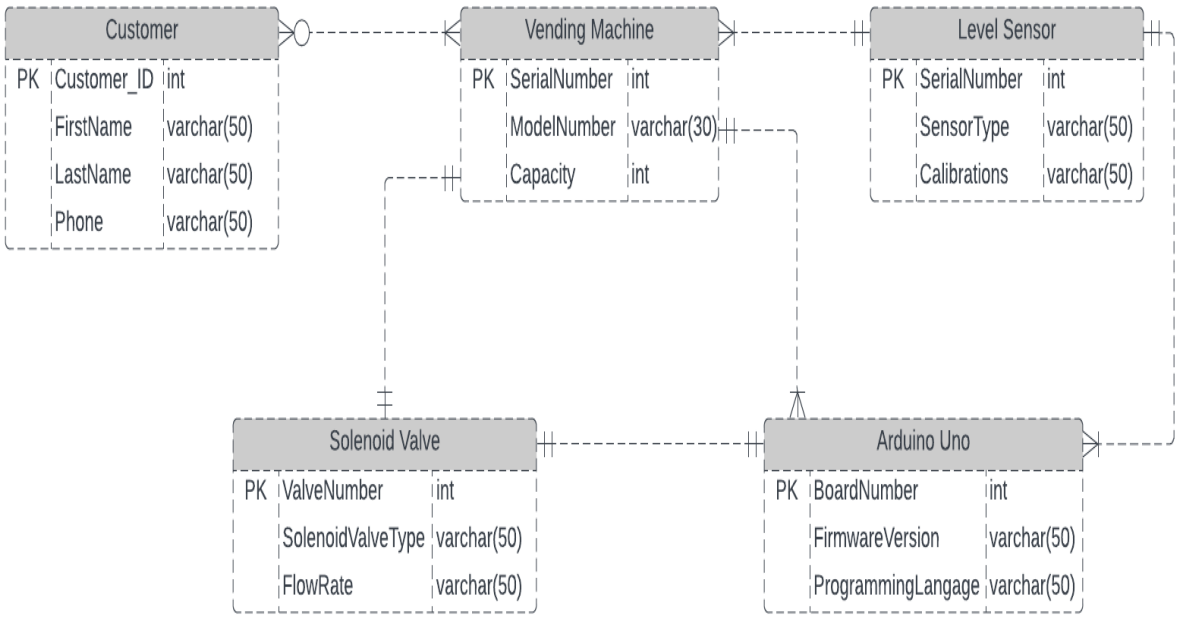


Figure 4:3 Entity Relationship Diagram

4.4.3.1 Database Schema

The Tables demonstrate the entities and the fields as well as their corresponding primary and foreign keys as integrated in the database design.

Table 4.4 shows the customer table.

Table 4.4 Customer table

Column Name	**Data Type**	**Index**
Customer_ID	Int(10)	Primary Key
FirstName	varchar(50)	
LastName	varchar(50)	
Phone	varchar(50)	

Table 4.5 shows the vending machine table.

Table 4.5 Vending Machine table

Column Name	**Data Type**	**Index**
SerialNumber	Int(10)	Primary Key
ModelNumber	varchar(30)	
Capacity	int(10)	

Table 4.6 shows the level sensor table

Table 4.6 Level Sensor table

Column Name	**Data Type**	**Index**
SerialNumber	Int(10)	Primary Key
SensorType	varchar(50)	
Calibrations	varchar(50)	

Table 4.7 shows the solenoid valve table

Table 4.7 Solenoid valve table

Column Name	**Data Type**	**Index**
ValveNuber	Int(10)	Primary Key
SolenoidValveType	varchar(50)	
FlowRate	varchar(50)	

Table 4.8 shows the Arduino Uno table

Table 4.8 Arduino Uno table

Column Name	**Data Type**	**Index**
BoardNumber	Int(10)	Primary Key
FirmwareVersion	varchar(50)	
ProgrammingLanguage	varchar(50)	

4.4.4 Wireframes of the system

The wireframe gives a visual representation of the system to be developed. The user interface of the web application and mobile application are illustrated. The researcher also elaborates on the functions of the wireframes.

Vending Machine Wireframe

Figure 4.4 shows the general proposed system layout. It contains the cooking oil holding container placed on an elevated surface. On the side is an LCD and keypad unit that is used to pass instructions to the vending machine. Attached to the cooking oil holding container is a solenoid valve that contains a tap.

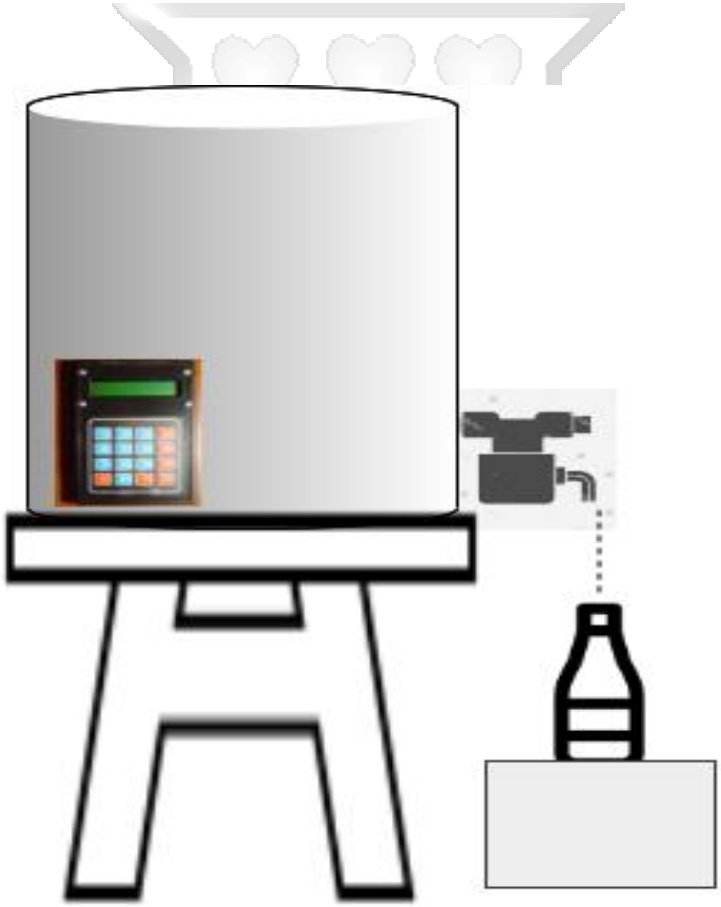


Figure 4:4 Vending Machine Wireframe

Placing an Order Wireframe

Figure 4.5 illustrates how the user powers on the vending machine and places their order. Once the vending machine is powered on, a “WELCOME” message will be displayed on the LCD Screen. The user must press the asterisk button (*) to for the vending machine to allow them to place their order hence “PLACE YOUR ORDER…” will displayed on the screen. The user then key’s in the desired amount and once the vending machine confirms the order then it will return the message, “PLACE YOUR CONTAINER…” instructing the user to place their holding container at the tap for the dispensing to begin.

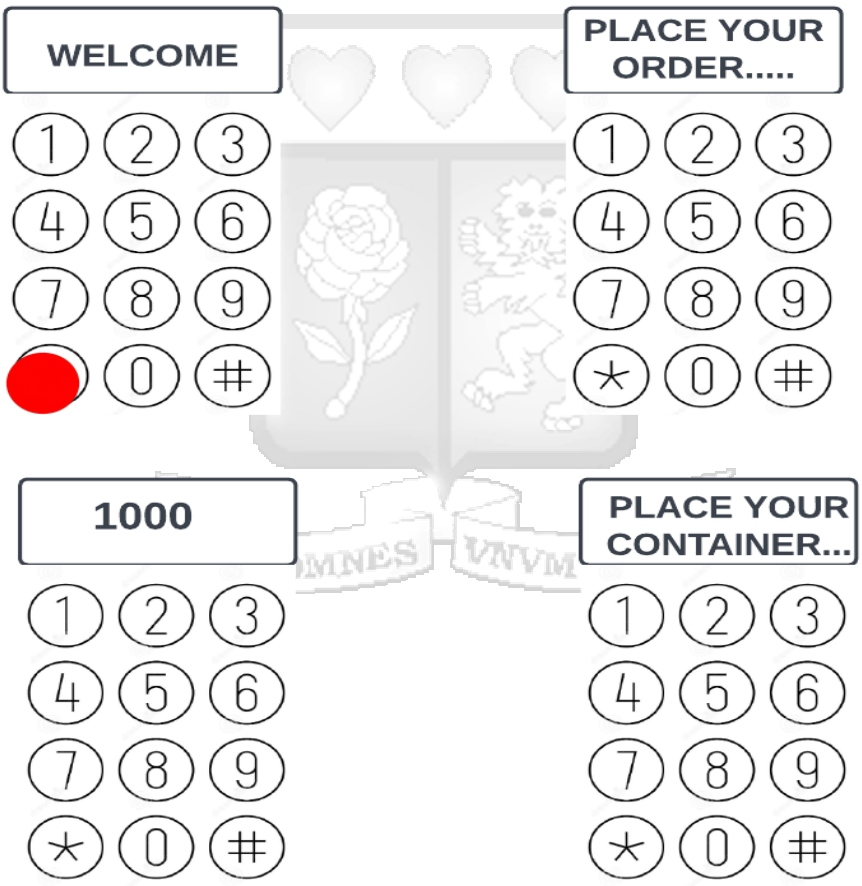


Figure 4:5 Placing an order wireframe

Check Status Wireframe

Figure 4.6 illustrates how the user can check the status of the vending machine. The user must press the hash button (#) to instruct the vending machine to check the its status. The vending machine will then display the message, “AVAILABLE AMOUNT IS…” followed by the actual amount of cooking oil in the vending machine.

Figure 4:6 Check Status Wireframe

Chapter Five: System Implementation and Testing

5.1 Introduction

This chapter focused on the implementation of the proposed solution to develop a low-cost automatic vending machine for small scale traders. Screenshots of the system were provided to illustrate how the system functions and the interaction the user has on the system. The vending machine was calibrated around the Arduino Uno as it the main controller of the system. The software code was written in Arduino programming language. Arduino IDE was used for compiling and uploading the sketch to ATmega328 microcontroller of the Arduino Board.

5.2 System Implementation

5.2.1 Key components of the Vending machine

Liquid Crystal Display (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module. A 16x2 LCD display is very basic module and is commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special and even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. The 16x2 LCD display is used in the development of this prototype. The image below shows the 16x2 LCD screen and the connections interfaced to the Arduino Uno microcontroller.

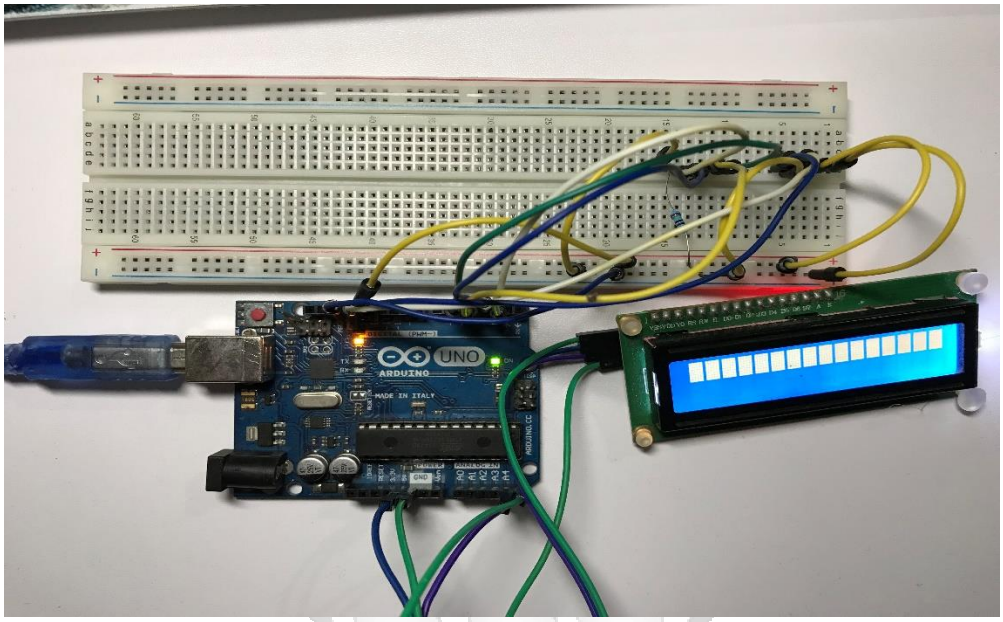


Figure 5:1 LCD connection to an Arduino Uno

Arduino Uno Microcontroller

An Arduino Uno is a microcontroller board which is based on the ATmega3. The ATmega328P is a low power CMOS 8-bit microcontroller based on the AVR enhanced Reduced Instruction Set Computing (RISC) architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs close to 1 MIPS per MHZ. This empowers system designers to optimize the device for power consumption versus processing speed (LoRa, 2015).

Figure 5.2 illustrates the configuration of the Arduino Uno

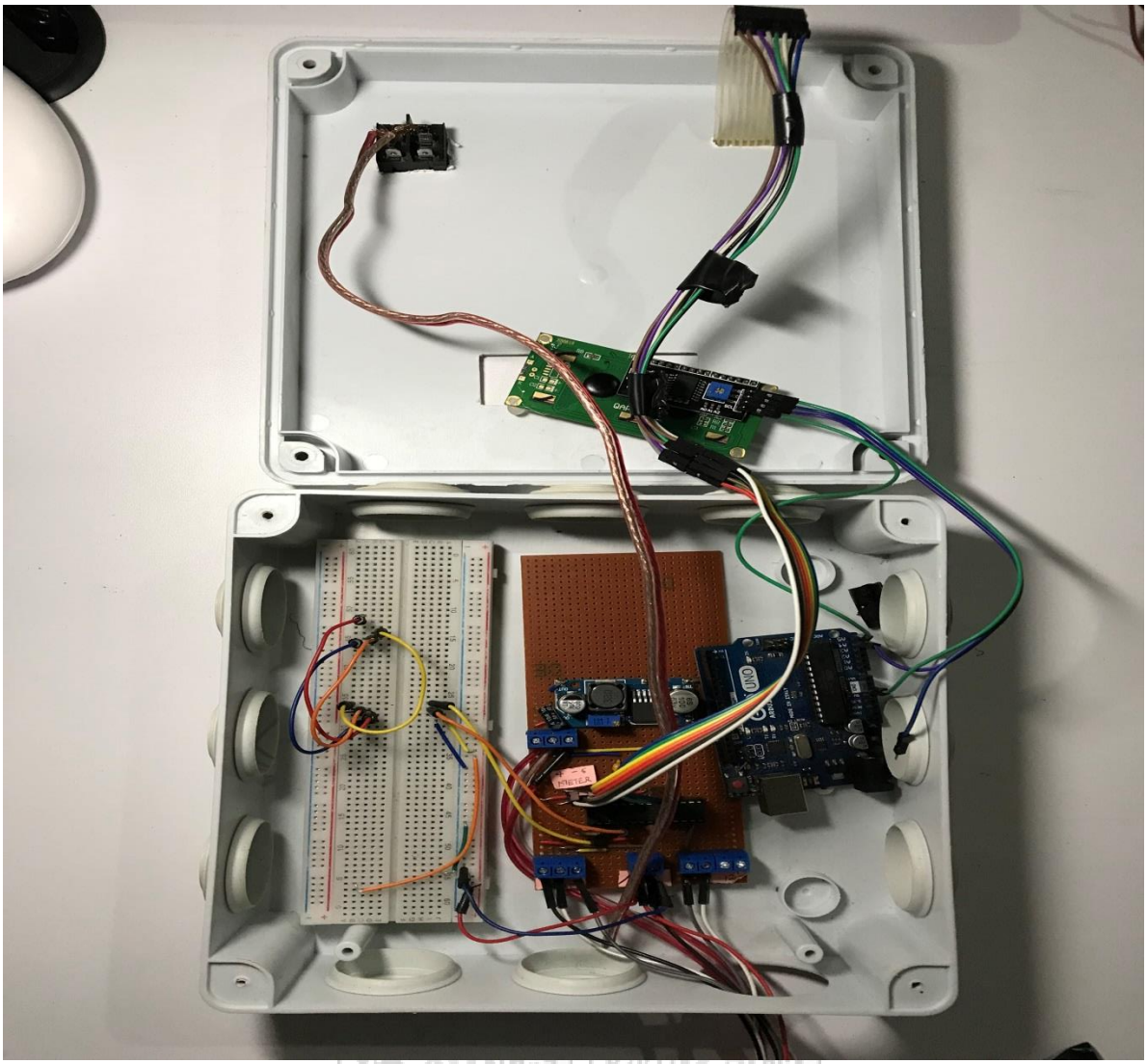


Figure 5:2Arduino Uno configuration

Solenoid Valve

A solenoid is a device that converts electrical energy into mechanical energy. It has a coil wound over a conductive material, this set-up acts as an electromagnet. Its operation principle is similar to relay, it has a coil inside it, which when energized, pulls the conductive material (piston) inside it, thus allowing the flow of the cooking oil and when de-energized it pushes the piston back in the previous position using the spring and again blocks the flow of liquid. Figure 5.3 illustrates the 12V solenoid valve used which is commonly used in controlling the flow of liquids.

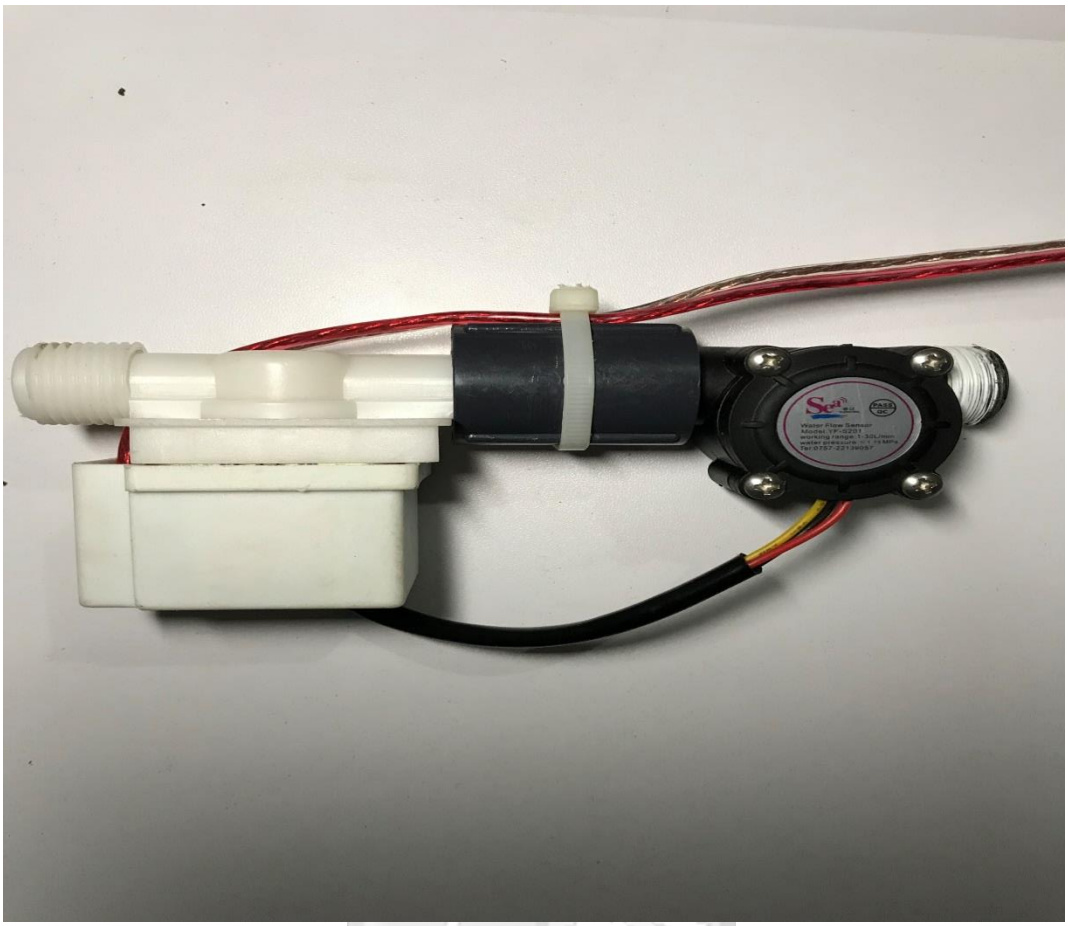


Figure 5:3 Solenoid Valve

5.2.2 Placing an Order Process

Figure 5.4 illustrates how the user powers on the vending machine and places their order. Once the vending machine is powered on, a “WELCOME” message will be displayed on the LCD Screen. The user must press the asterisk button (*) to for the vending machine to allow them to place their order hence “PLACE YOUR ORDER…” will displayed on the screen. The user then key’s in the desired amount and once the vending machine confirms the order then it will return the message, “PLACE YOUR CONTAINER…” instructing the user to place their holding container at the tap for the dispensing to begin.

Figure 5:4 Placing an Order

5.2.3 Checking Status of the Vending Machine

Figure 5.5 illustrates how the user can check the status of the vending machine. The user must press the hash button (#) to instruct the vending machine to check the its status. The vending machine will then display the message, “AVAILABLE AMOUNT IS…” followed by the actual amount of cooking oil in the vending machine.

Figure 5:5 Check Status

5.3 System Testing

This section discusses the various tests undertaken by the researcher and the users of the vending machine in order to fulfil the functional and non-functional requirements of the system.

5.3.1 Functional Testing

Functional testing was done to ascertain that the vending machine meets the requirements that it was intended to perform. The following tests were carried out.

Table 5.1 Placing an Order

Test Case Name: Place Order		**Test Case: 1**	
Brief Description: Users access the vending machine and place their cooking oil order			
Pre-condition: The user must power on the vending machine and press the asterisk (*) button			
Step	**Action**	**Expected results**	**Pass/Fail**
1.	User turns on the vending machine	The vending machine turns on and displays a welcome message	Pass
2.	User clicks on the asterisk button	The vending machine displays "PLACE YOUR ORDER" message	Pass
3.	The user keys in the amount of cooking oil required	The vending machine displays "PLACE YOUR CONTAINER" message	Pass
Post condition: The cooking oil is dispensed to the user's container			

Table 5.2 Check Status

Test Case Name: Check Status		**Test Case: 2**	
Brief Description: The vendors checks the amount of cooking oil available in the vending machine			
Pre-condition: The vendor must switch on the vending machine and press the hash (#) button			
Step	**Action**	**Expected results**	**Pass/Fail**
1.	The vendor turns on the vending machine	The vending machine turns on and displays a welcome message	Pass
2.	Vendor clicks on the hash button	The vending machine displays "AVAILABLE AMOUNT" message	Pass

Post condition: The available amount of cooking oil is displayed on the LCD

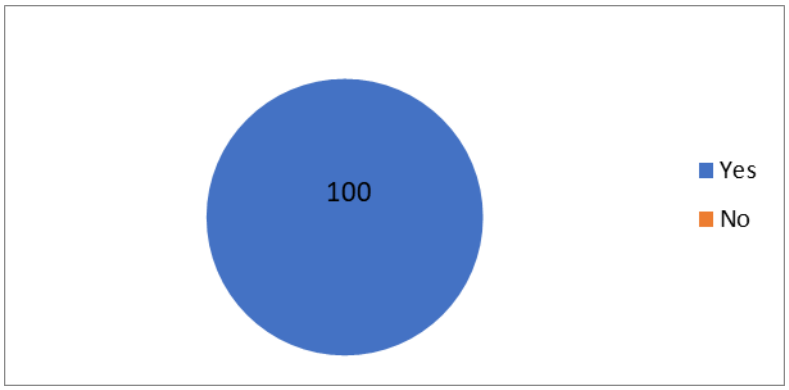
Table 5.3 Dispensing Accuracy

Test Case Name: Dispensing Accuracy		**Test Case: 3**	
Brief Description: Users/Vendor access the vending machine and place their cooking oil order			
Pre-condition: The user/vendor must power on the vending machine and press the asterisk (*) button			
Step	**Action**	**Expected results**	**Pass/Fail**
1.	User/vendor turns on the vending machine	The vending machine turns on and displays a welcome message	Pass
2.	User clicks on the asterisk button	The vending machine displays "PLACE YOUR ORDER" message	Pass
3.	The user keys in the amount of cooking oil required	The vending machine displays "PLACE YOUR CONTAINER" message	Pass
4.	The vending machine starts dispensing the cooking oil	The vending machine dispenses the cooking oil	Pass
Post condition: The vending machine accurately dispenses the required amount of cooking oil			

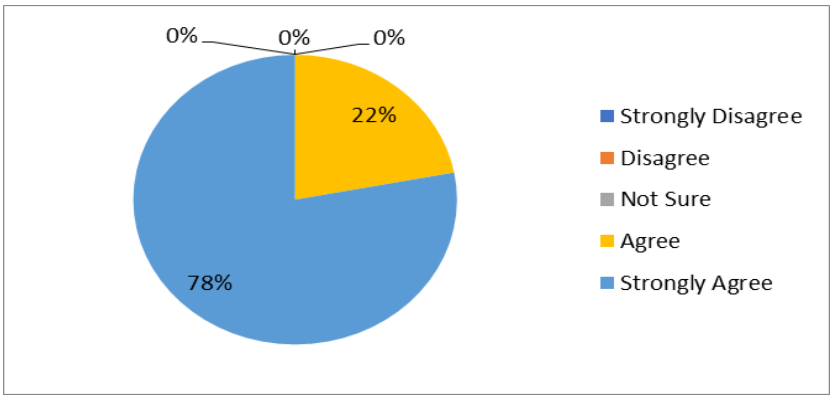
5.3.2 User Testing

The user testing was done by the end users of the vending machine. The testing was done to achieve the following: the ease of use, user friendliness, user acceptance and functionality.

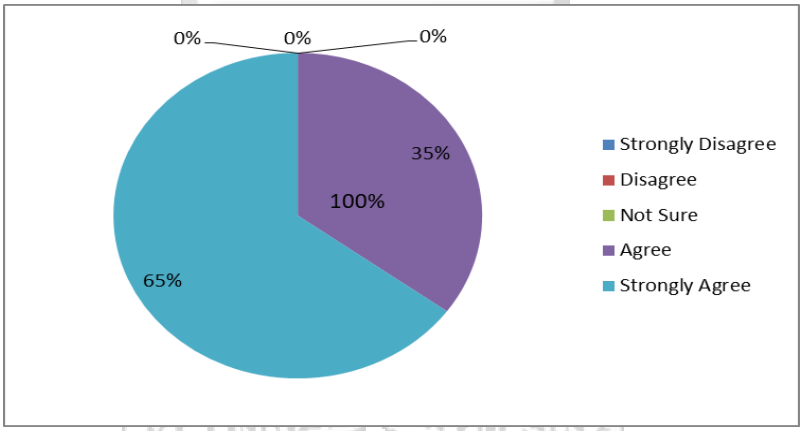
a) All ten users who participated in the user testing found the interface of the vending machine on the basis of its look and feel as attractive



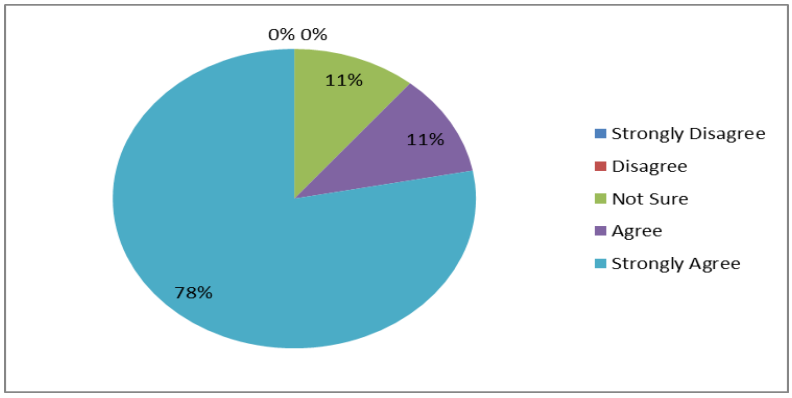
b) The respondents who participated in the vending machine usability testing 78% strongly agree and 22% agree that “It was simple using and navigating the vending machine”



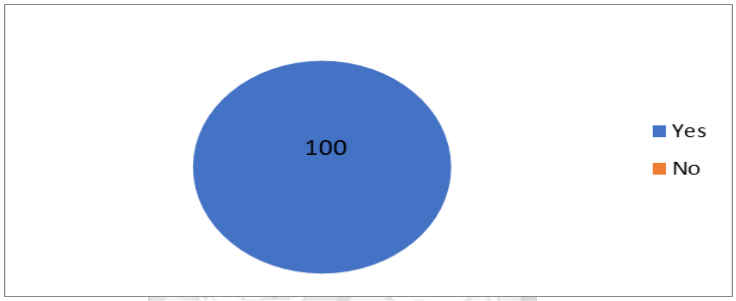
c) On “feedback and instructions provided by the vending machine are clear” 65% rated Strongly Agree and 35% rated Agree.



d) On the suitability test attribute “the vending machine was easy to learn even for the first time” 78% strongly agreed, 11% agreed while 11% were not sure that the vending machine was ease to learn.



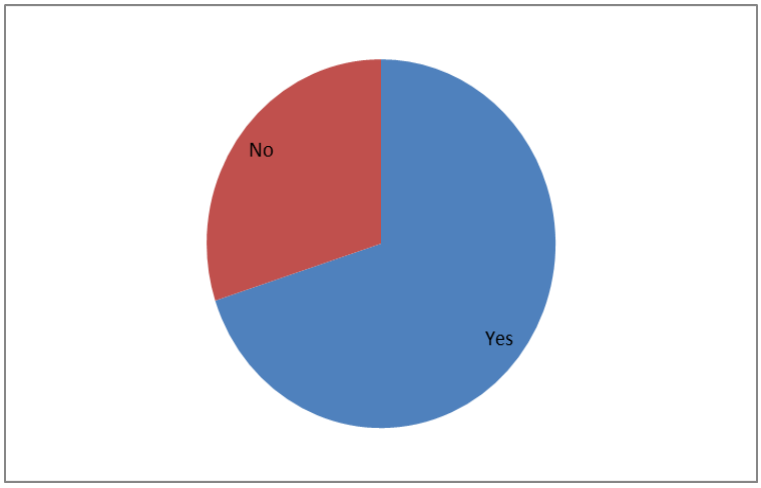
e) Finally on "Does the system functionality meet the user requirements" all users agreed that vending machine meets the user requirements



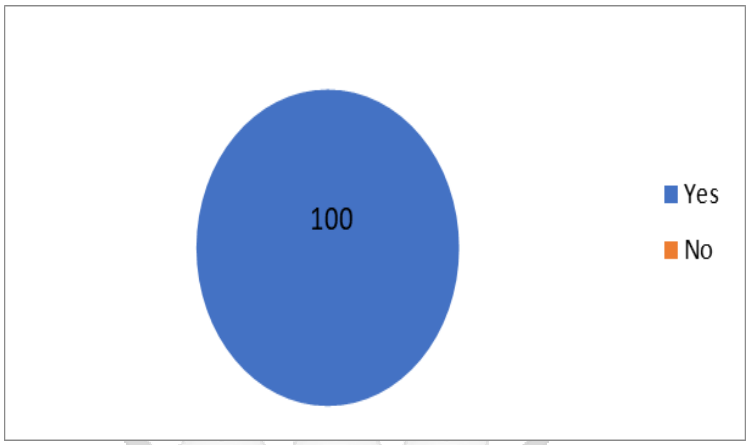
5.3.3 Validity Testing

Validation testing was done to validate whether the vending machine would assist small scale traders in accurately measuring cooking oil accurately and efficiently. A questionnaire was designed and given to the end users to respond.

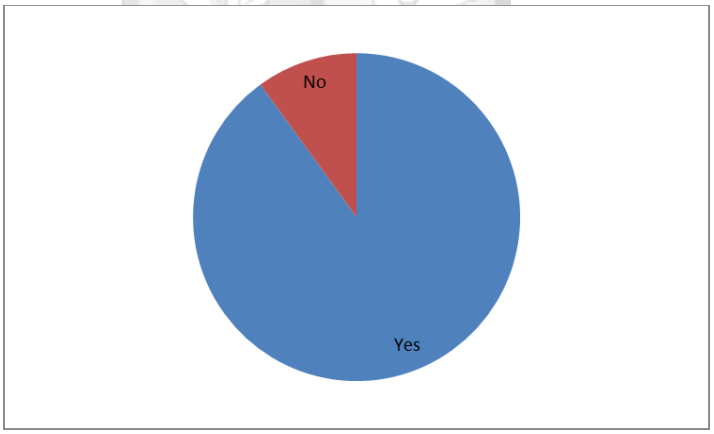
a) Seven of the respondents who participated on the user testing also participated in the validity testing while 3 did not



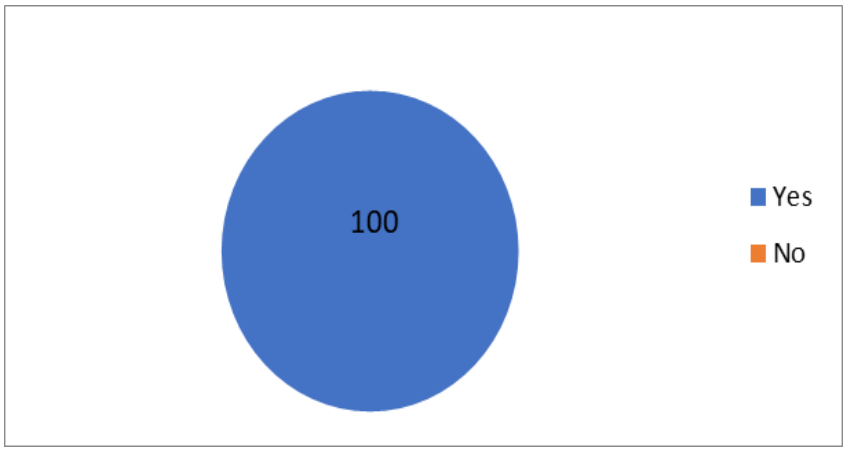
b) All respondent agreed that the functionalities provided by the vending machine assist in accurately dispensing cooking oil, eliminating human intervention



c) Nine of the respondents are satisfied with the solutions provided by the vending machine as far as assisting small scale traders in the automation of dispensing cooking oil while one is not.



d) All respondent agreed that they would recommend the vending machine to other small scale traders


100
Yes
No

Chapter Six: Discussion

6.1 Introduction

The system developed, as detailed in Chapter 5, was tested to ascertain whether it offered the required functionalities as identified in literature. This chapter, therefore, analyzed the findings made in this study, relating them with the research objectives and highlighting the merits and demerits of the proposed application.

6.2 Findings and Achievements

The study focused mainly on implementing a low cost cooking oil vending machine for small scale traders. Most small-scale traders have limited resources and small spaces for operation, introducing the vending machines present in the market would be very costly and will occupy a lot of space leaving them with limited or no space to operate in. Therefore, small-scale traders have remained comfortable with the old ways of manually measuring liquids, in this case the cooking oil, as the new technology in liquid dispensing does not cater to their needs.

The study revealed the possibility of automating the measuring process for the trader by fabricating a low cost automatic vending machine by use of an Arduino microcontroller. Though there are some earlier versions of these machines available, these machines do not focus on providing a low cost, simple design that could be easily accessed by small scale traders. The implemented vending machine enabled easy and accurate measurement in the selling of cooking oil eliminating physical measuring. It is a cheap and efficient way of selling cooking oil, simple and specific to a local seller.

The automatic cooking oil vending machine made it possible for the desired amount of oil to be dispensed accurately. This led to elimination of human interaction in the measuring and dispensing process as a result aiding the trader in cutting of losses that was caused due to inaccurate measuring.

6.3 Review of the Research objectives in relation to the developed system

In this study, a low cost automatic vending machine was designed and developed based on the research objectives. This section describes the various objectives of the research in relation to the findings or results. In line with the first objective, which was to evaluate the existing

technologies used by automatic vending machines, it came out from the study that generally information to the customers was not sufficient. The study showed that the different vending machine technologies used are either too complex or inaccessible to the small scale traders. The study clearly depicted that a low cost, simple and efficient vending machine would be of great help to the small scale traders.

The second objective was to investigate the various limitations of the current vending machines for small scale traders. This objective was achieved by reviewing literature, reports and documentation obtained which showed the benefits automating the cooking oil vending process for small scale traders. From the literature review done, it informed that the expense of installing, operating and maintaining the vending machines currently in the market is too high for the small scale traders. It is for this reason that most traders opt out into adopting the new vending machines technology. The developed system and deployed automatic cooking oil vending machine addresses this issue by ensuring that the cost used to implement this vending machine is affordable for the small scale traders. Findings from the literature indicate the cost of running the vending machine between KES 120,000–700,000 whereas the proposed system only cost between KES 8,500 to 12,000 depending on the vendor's specifications.

The last objective was to design, develop and test a low cost automatic cooking oil vending machine for small scale traders. The system was designed and developed and it shows how the automatic vending machine would work. A Usability and Validation Test was conducted to ascertain the proposed system functionalities and it was concluded that the system functioned as required.

Chapter Seven: Conclusion and Recommendations

7.1 Conclusion

This research was carried out to develop a low cost automating cooking oil vending machine for small scale traders with an aim of eliminating physical measurements of the cooking oil.

The study was done within Nairobi County by designing and developing a system towards this end. Prior to design and development, a comprehensive study was carried out to determine the existence of the problem and viability of the study.

This low cost vending machine not only addresses the physical measuring challenges but with proper utilization it offers a platform which can enable the small scale traders not only sell cooking oil from the system but upscale it to include other liquids.

The successful implementation of this system does guarantee efficiency, accountability, transparency and effectiveness in selling of cooking oil by small scale traders.

7.2 Recommendations

The vending machine is of great importance to the small scale traders' community. The proposed system aids in accurate dispensing of cooking oil which eliminates losses caused due to the physical measurements.

A key recommendation of this study is that the vending machine adopts use of a USSD code or QR Code scanner. This will eliminate the issue of having to key in instructions using the keypad on the vending machine. The whole process can simply be done on a mobile or web application, these applications can be used to send instructions to the vending machine.

Another recommendation would be to upscale the vending machine to accommodate other liquids sold in stores such as paraffin, liquid soaps and water.

7.3 Future Work

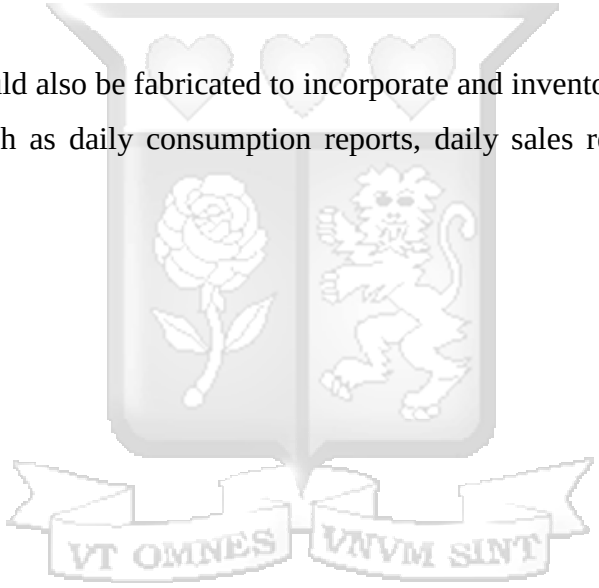
The researcher noted that there was more that could be done to the vending machine to ensure optimal utilization of its functionalities

The vending machine could be expanded in a way that it can accommodate other liquids such as water, liquid soap and paraffin. This will diversify the vending machine and not only limit it one liquid per vending machine.

The system could also adopt the use of a USSD code or QR Code scanner. This will eliminate the issue of having to key in instructions using the keypad on the vending machine. The whole process can simply be done on a mobile or web application, these applications can be used to send instructions to the vending machine.

The platform could also allow the vendor receive alerts on when to refill the vending machine instead of the vendor to always have to check the status of the vending machine every now and then.

The vending machine could also be fabricated to incorporate and inventory systems. This can aid in generating reports such as daily consumption reports, daily sales report and monthly sales report.



References

Abdulla, R., Yosua Rantung Lau Chee Young Raed Abdulla, G., Lumpur, K., & Kuala Lumpur, M. (2022). Vending Machine Electricity Usage Optimizer Using Automated Relay and AI for Smart Retailing Based on the Concept of Internet of Everything (IOE). *Journal of Applied Technology and Innovation*, *6*(3), 2600–7304. https://www.researchgate.net/publication/361901943

Anubhaw;, K., & Rani, P. (2016). Automation of Beverage Vending Machine using PLC and SCADA. *An International Journal of Engineering & Technology (A*, *3*(5), 78–84.

Badgujar, N. A. (2017). *PLC based automation of multiple fluid vending machine*.

Baladhandabany, D., Gowtham, S., Kowsikkumar, T., Gomathi, P., & Vijayasalini, P. (2015). PLC based automatic liquid filling system. *International Journal of Computer Science and Mobile Computing*, *4*(3), 684–692. www.ijcsmc.com

Bebe Omedo, B., Van der Lee, J., & Kilelu w, C. (2018). *Milk Retailing Innovation in Kenya andConsumers Perceptions of Safety*. *March 2020*, 010. http://www.3r-kenya.org/

Desai, P. S. S., Jadhav, S. M., Patil, P. S., Sambhaji, G. N., & Card, A. R. (2017). Automatic Chocolate Vending Machine By Using Arduino Uno. *International Journal of Innovative Research in Computer Science & Technology*, *5*(2), 226–229. https://doi.org/10.21276/ijircst.2017.5.2.2

Ismailov, A. S., & Jo'rayev, Z. B. (2022). Study of arduino microcontroller board. *"Science and Education" Scientific Journal*, *3*(3).

Kaguara, A., & Wanjiru, M. (2012). *Digital Divide: the Glaring Reality*. 1–26.

Kumar, M. D. (2018). DEVELOPMENT OF LOW COST PORTABLE AUTOMATIC MILK VENDING. *International Journal of Pure and Applied Mathematics*, *119*(18), 2639–2648.

Liz, S. (n.d.). *Digital Divide: The Technology Gap between the Rich and Poor*.

Los, U. M. D. E. C. D. E. (2015). *RN2483 Low-Power Long Range LoRa Technology Transceiver Module Data Sheet*.

Ratnasri, N., & Sharmilan, T. (2021). Vending Machine Technologies : A Review Article International Journal of Sciences : Vending Machine Technologies : A Review Article. *International Journal of Sciences: Basic and Applied Research*, *58*(June 2021), 160–166.

Wong, K. K., Atikhah, N., Samah, A., Sahimi, M. S., & Othman, W. A. F. W. (2019). Development of Reverse Vending Machine using Recycled Materials and Arduino Microcontroller. *International Journal of Engineering Creativity and Innovation*, 7–16.

Appendices

Appendix A: User Testing Questionnaire

Dear Respondent,

I am a Master's student in the Faculty of Information Technology, Strathmore University

conducting a research entitled, A low cost automatic cooking oil vending machine for small scale traders.

You have been selected to form part of this research study. I kindly request you to complete the

questionnaire below. The information requested is needed for academic purposes only and will be

treated in strict confidentiality.

Kind Regards,

Gloria Koi

1. How do you find the user interface of the vending machine on the basis of its look and feel? (Choose ONE)

o Attractive

o Average

o Not Attractive

2. How would you rate the usability of the whole vending machine? (Choose ONE)
   a) It was simple using and navigating the vending machine

o Strongly Agree

o Agree

o Not Sure

o Disagree

o Strongly Disagree

   b) The feedback and instructions provided are clear

o Strongly Agree

o Agree

o Not Sure

o Disagree

o Strongly Disagree

c) The vending machine was easy to learn even for the first time

o Strongly Agree

o Agree

o Not Sure

o Disagree

o Strongly Disagree

3. Does the system functionality meet the user requirements? (Choose ONE)

o Yes

o No

Thank you for your time, I highly appreciate

Appendix B: Validation Questionnaire

Dear Respondent,

I am a Master's student in the Faculty of Information Technology, Strathmore University

conducting a research entitled, A low cost automatic cooking oil vending machine for small scale traders.

You have been selected to form part of this research study. I kindly request you to complete the

questionnaire below. The information requested is needed for academic purposes only and will be

treated in strict confidentiality.

Kind Regards,

Gloria Koi

1. Did you take part in the user testing of the vending machine?

o Yes

o No

2. Does the functionalities provided by the vending machine assist in accurately dispensing cooking oil, eliminating human intervention?

o Yes

o No

3. Are you satisfied with the solutions provided by the vending machine as far as assisting small scale traders in the automation of dispensing cooking oil?

o Yes

o No

4. Would you recommend the vending machine to other small scale traders?

o Yes

o No

Thank you for your time, I highly appreciate

Appendix C: Other Screenshots

The figures illustrate the code used for passing instructions to the Arduino Uno microcontroller.

*Liquid_Vending - Notepad

File Edit Format View Help

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(4,5,6,7,8,9); //(RS, EN, D4, D5, D6, D7)

//you can add multiple tags no.
String tag1="4A00C3978B95";//you can change tag no.
String tag2="4A00C35BBA86";

byte statusLed    = 13;
byte sensorInterrupt = 0;  // 0 = digital pin 2
byte sensorPin       = 2;

int tap=3;//relay is connected which triger solenoid

float calibrationFactor = 4.5;

volatile byte pulseCount;

float flowRate;
unsigned int flowMilliLitres;
unsigned long totalMilliLitres;
unsigned long quantity =1000;//1000ml-you can change as per your requirment
unsigned long flow_reading = 0;
unsigned long oldTime;

void setup()
{
  Serial.begin(9600);
  lcd.begin(16,2);
  lcd.setCursor(5,0);
  lcd.print("WELCOME");
  lcd.setCursor(0,1);
  lcd.print("PLACE YOUR ORDER");

  pinMode(statusLed, OUTPUT);
  pinMode(tap,OUTPUT);
  digitalWrite(statusLed, HIGH);

  while(!Serial.available()){
    delay(1000);
  }

  digitalWrite(tap, HIGH);
  pinMode(sensorPin, INPUT);
  digitalWrite(sensorPin, HIGH);

  pulseCount        = 0;
```

```
  flowRate          = 0.0;
  flowMilliLitres   = 0;
  totalMilliLitres  = 0;
  oldTime           = 0;
  attachInterrupt(sensorInterrupt, pulseCounter, FALLING);
}
void loop()
{
String tagdata=Serial.readString();
if(tagdata==tag1)//person1 tag match if match he/she will get 1litre of liquid
{
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("PLACE YOUR CONTAINER");
  lcd.setCursor(4,1);
  lcd.print("person1");
  digitalWrite(tap,1);
  while(flow_reading < quantity){
                    flow_reading = getFlowData();
                    lcd.clear();
                    lcd.setCursor(0,0);
                    lcd.print("Flow Amount ");
                    lcd.setCursor(0,1);
                    lcd.print(flow_reading);

                    delay(1000);

                }

                //solenoid  to close via relay
                digitalWrite(tap, LOW);

}

else if(tagdata==tag2)//person2 tag match if match he/she will get 1litre of liquid
{
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("put pot");
  lcd.setCursor(0,1);
  lcd.print("person 2");
  digitalWrite(tap,1);
   while(flow_reading < quantity){
                    flow_reading = getFlowData();
                    lcd.clear();
```

```
                    lcd.setCursor(0,0);
                    lcd.print("Flow Amount ");
                    lcd.setCursor(0,1);
                    lcd.print(flow_reading);

                    delay(1000);

                  }

                  //solenoid  to close via relay
                  digitalWrite(tap, LOW);
                  lcd.clear();
                  lcd.setCursor(0,0);
                  lcd.print("Remove pot");
}
}
unsigned long getFlowData(){

  detachInterrupt(sensorInterrupt);

  flowRate = ((1000.0 / (millis() - oldTime)) * pulseCount) / calibrationFactor;

  oldTime = millis();

  flowMilliLitres = (flowRate / 60) * 1000;
  totalMilliLitres += flowMilliLitres;

  unsigned int frac;


  pulseCount = 0;
  attachInterrupt(sensorInterrupt, pulseCounter, FALLING);

  return totalMilliLitres;

}

void pulseCounter()
{
  // Increment the pulse counter
  pulseCount++;
}
```

Appendix D: Other Screenshots

Overall appearance of the vending machine

Appendix E: Turnitin Report

Turnitin Originality Report

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