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QUEZON CITY UNIVERSITY

"POWERWALK": CONVERTING FOOT TRAFFIC INTO SUSTAINABLE ENERGY, UTILIZING PIEZOELECTRIC TRANSDUCERS WITH RFID AND DATA VISUALIZATION FOR EFFICIENT POWER GENERATION

A Capstone Project Documentation
Presented to
The College of Computer Studies
QUEZON CITY UNIVERSITY

In Partial Fulfillment of the
Requirements for the Degree
BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY

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COLLEGE OF COMPUTER STUDIES

APPROVAL SHEET

In partial fulfillment of the requirements for the degree **BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY**, this Capstone project entitled **"POWERWALK": CONVERTING FOOT TRAFFIC INTO SUSTAINABLE ENERGY, UTILIZING PIEZOELECTRIC TRANSDUCERS WITH RFID AND DATA VISUALIZATION FOR EFFICIENT POWER GENERATION** has been prepared and submitted by Arella, Vincent G., Bibat, Ian Benjamin, Bustamante, Jefferson, Espeña, Jeremiah B., Esperanzate, Christian, Estonactoc, Kiesha Mel C., Evangelista, Jhun Rey L., Fabia, Aaron Urich C., Fernandez, Lois Meek L., Jacobe, John Carlo P., Lunas, Danielle L., Tulod, Noahmie S., Uy, Timothy Joshua F., who are hereby recommended for project presentation.

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DEDICATION

This research is dedicated to the researcher's unyielding willingness, sacrifices and effort in finishing this project. This work is dedicated wholly to the people who gave their support and inspiration to the researchers.

Our teachers and parents, who have been our main supporters through all the challenges we've overcome, who have continuously provided us with wisdom throughout our project.

This project is also dedicated to our friends who have always been a constant reminder to the researcher's hard work and gave joy despite the hurdles and challenges this academic school year.

ACKNOWLEDGMENT

The researchers would like to express their overwhelming gratitude for the never-ending support they received while bringing this study to reality.

First and foremost, to Almighty God, the source of wisdom and strength of the researchers who went beyond their limits as they faced hardships in the process of developing the project. His soothing lights comforted the minds and spirits of the proponents during their darkest, conflicted times.

Ms. Rose Anne Tanjente, our Capstone Mentor, for her knowledge and guidance to the researchers in completing this study. Her guidance and knowledge lent throughout the completion of this system are sincerely appreciated.

To our team members, for their effort and resilience in completing this study. The researchers also extended their grateful hearts to Quezon City University for the opportunity to learn in developing a system. The researchers never lost enthusiasm as they received full support from the institution.

EXECUTIVE SUMMARY

Title : **"POWERWALK": CONVERTING FOOT TRAFFIC INTO SUSTAINABLE ENERGY, UTILIZING PIEZOELECTRIC TRANSDUCERS WITH RFID AND DATA VISUALIZATION FOR EFFICIENT POWER GENERATION**

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Date Completed : **March 2025**

Keywords : **PiezoElectric Sensors, Charging Station, Mechanical Energy, Foot Traffic**

Mobile phones are essential in today's world, but keeping them charged is a common problem. The POWERWALK project addresses this issue by creating an eco-friendly mobile charging station for Quezon City University (QCU). It uses kinetic energy from foot traffic, converted into electricity by piezoelectric transducers, to provide a sustainable and convenient charging solution for students. The system also integrates RFID technology for secure access and data visualization to monitor energy production and usage. This project promotes the use of alternative energy sources, reduces reliance on conventional electricity, and supports QCU's commitment to sustainability.

The main goal of POWERWALK is to develop a user-friendly and eco-conscious charging station that demonstrates the potential of kinetic energy harvesting. Specific objectives include building the hardware device, creating an energy monitoring system, implementing RFID for student access, converting foot traffic into mechanical energy, and ensuring the system meets ISO/IEC 25010 software quality standards in areas like functionality, security, and usability.

POWERWALK follows an Agile methodology combined with quantitative research to ensure continuous improvement and data-driven development. The project is divided into phases: planning the system's functionality, designing the

layout of piezoelectric sensors and components (such as Arduino Uno, RFID, LCD screens, Node MCU ESP8266, Voltage Sensor), developing a prototype, testing performance and user feedback, and deploying the system. Testing focused on power output, RFID accuracy, and foot traffic patterns, ensuring an efficient and reliable charging station. The final deployment involves placing the device in a high-traffic area at QCU, educating users on its features, and gathering feedback for further improvements.

The POWERWALK charging station was successfully developed and tested, proving that piezoelectric energy harvesting is a viable and eco-friendly power source. The RFID authentication system ensures secure and controlled access, preventing unauthorized use. Evaluated using the ISO/IEC 25010 Software Quality Model, the system meets standards for functionality, efficiency, security, usability, and maintainability. To further improve its performance, recommendations include increasing energy storage capacity, enhancing RFID security, optimizing power output, expanding wireless charging capabilities, scaling up by installing more piezoelectric tiles in busy areas, and improving tile durability. These improvements will ensure consistent charging performance, maximize energy generation, and enhance the overall reliability of the system.

TABLE OF CONTENTS

COPYRIGHT PAGE ...……...…….....

TITLE PAGE ...……...……..... II

APPROVAL SHEET……. III

DEDICATION …….. IV

ACKNOWLEDGEMENT …… V

EXECUTIVE SUMMARY…… VI

TABLE OF CONTENTS…….. IX

LIST OF TABLES……. XI

LIST OF FIGURES……...…….. XII

LIST OF APPENDICES……. XIV

Chapter 1: Capstone Project and Background……1

1.1 Introduction……...…… .1

1.2 Background of the Study ……4

1.3 Objective of the Study ……..... 8

General Objective…… .8

Specific Objectives…… .8

1.4 Significance of the Study …… .10

1.5 Scope and Delimitations of the Study……....12

Scope……12

Limitation/Delimitation……14

1.6 Theoretical Framework ……15

1.7 Conceptual Framework ……22

1.8 Definition of Terms ……24

Chapter 2: Review of Related Literature and Studies…… 26

2.1 Review of Foreign Literature…….26
2.2 Review of Local Literature ……35
2.3 Synthesis of the Reviewed Literature and Studies ……48
Chapter 3: Design & Methodology……...50
3.1 Research Methodology……...50
3.2 System Development Methodology…….54
3.3 Sampling Technique……...58
3.4 Data Gathering Technique…….61
3.5 Requirement Analysis and Documentation ……...64
3.6 Software and Hardware Development Requirements……..65
Functional Requirements……...66
Non-Functional Requirements……..68
3.7 Software/System Development Method…….69
3.8 System Requirement Model……...74
3.9 Project Development Cost (Cost – Benefit Analysis)……..91
3.10 Development and Testing…….95
Development…….96
Testing…….97
3.11 Data Analysis Plan…….....102
3.12 Implementation Plan……..104
Chapter 4: Results and Discussion ……110
Chapter 5: Summary, Conclusion and Recommendation…….....135
5.1 Summary of Findings……..135
5.2 Conclusions……... 137
5.3 Recommendations…….140
REFERENCES ……...141
APPENDICES ……...145

List of Tables

Table No.	Table Title	Page No.
3.1	Software Development Requirements	65
3.2	Hardware Development Requirements	66
3.3	Event Table	69
3.4	Project Development Cost of Powerwalk Charging	91
3.5	Black Box Testing	97
3.5	Software Testing Plan	97
3.6	Hardware Testing Plan	99
3.7	Likert Scale Interpretation	106
3.8	Implementation Plan	107
4.1	Performance Efficiency (Student)	112
4.2	Security (Student)	113
4.3	Usability (Student)	114
4.4	Compatibility (Student)	115
4.5	Reliability (Student)	116
4.6	Maintainability (Admin)	117
4.7	Functional Suitability (Admin)	118
4.8	Portability (Admin)	119
4.9	Performance Efficiency (Admin)	120
4.10	Usability (Admin)	121
4.11	Security (Admin)	122
4.12	Compatibility	123

LIST OF FIGURES

Figure No.	Name of Figure	Page No.
1.1	Inertia Harvester Theory	16
1.2	Dielectric Theory	18
1.3	Piezoelectric Theory	20
1.4	Conceptual Framework	22
3.1	Agile Methodology	55
3.2	System Flowchart (Student)	74
3.3	System Flowchart (Log In)	75
3.4	System Flowchart (Dashboard)	76
3.5	System Flowchart (RFID Register)	77
3.6	Context Diagram	78
3.7	Data Flow Diagram - Level 1	79
3.8	Data Flow Diagram - Level 2	80
3.9	Use Case Diagram	81
3.10	Entity Relationship Model	82
3.11	Hardware 3d and 2d Prototype	83
3.12	Top Box Prototype	84
3.13	Lower Box Prototype	85

Figure No.	Name of Figure	Page No.
3.14	Schematic Diagram of Top Box	86
3.15	Schematic Diagram of Arduino Uno and RFID-RC522	87
3.16	Full Connection of Hardware Wirings Blueprint	88
3.17	Piezo Tiles Blueprint	89
3.18	Flow Circuit Diagram	109
4.1	Screenshot of Software with Explanation of SO #2	111
4.2	LCD of Hardware with Explanation of SO	111
4.3	Powerwalk Charging Station with Explanation of SO #4	112
4.4	Piezo Tile with Explanation of SO #4	112
4.5	Before and After of Phone Battery after 15 charging time with Explanation to SO# 4	116
4.6	Screenshots of the Scanning of Unregistered RFID Card with Explanation to SOP #5	119
4.7	Screenshots of the Scanning of Registered RFID Card with Explanation to SOP #5	119

Figure No.	Name of Figure	Page No.
4.8	Screenshots of the Charging Ports with Explanation to SOP #6	120

List of Appendices

Appendix Letter	Table Title	Page No.
A	GANTT CHART	144
B	NETWORK LAYOUT	145
C	SYSTEM EVALUATION QUESTIONS	146
D	TRANSCRIPT OF INTERVIEW	149
E	PHOTO DOCUMENTARY DURING SYSTEM EVALUATION	154
F	PHOTO DOCUMENTARY DURING DATA GATHERING	157
G	SYSTEM SOURCE CODE	158
H	SYSTEM SCREENSHOTS	170
I	CONSULTATION LETTER	177
J	CERTIFICATION OF SAFETY COMPLIANCE	178
K	CURRICULUM VITAE	179
L	CERTIFICATION OF THE PROOFREADER	192
M	CERTIFICATE OF COPYRIGHT APPLICATION	193
N	TURN IT IN RESULTS	194

CHAPTER 1

PROJECT CONTEXT AND BACKGROUND

1.1 Introduction

In today's fast-paced world, our cell phones have become an integral part of our daily lives. We use them for everything from communication to navigation, and we rely on them to keep us connected at all times.

According to a statistical report made by DateReportal (2024), The most used Electronic Device is mobile phones with 97.9% and a smartphone as second with a 97.7 percentage. As students we are always using our phones by many different reasons, may it be for communications, or aid for assignments via the internet, or for leisure like games and entertainment. In an article written by Fabio Duterte entitled "Time Spent Using Smartphones (2024 Statistics)" that an average person spends 4 hours and 37 minutes on their phone each day. But, with all this usage comes one major problem – battery life, our phone drains at a certain point.

To keep our phones charged, we need a reliable and convenient charging solution. This is where cell phone charging stations come in.

The Project entitled, "POWERWALK": Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data

Visualization for Efficient Power Generation is an eco-friendly mobile charging station powered by Converted Kinetic Energy to Mechanical Energy from Foot Traffic being given by the people coming in and out of the school.

With the increasing focus on renewable energy solutions, there is a need to utilize alternative/available resources in a way that benefits both the environment and the campus community. This project introduces a solution that harnesses foot traffic as a renewable energy source to provide free charging stations for students of QCU.

The proponents seek to demonstrate the feasibility of using alternative energy to address everyday needs while reducing reliance on conventional electricity. By implementing this system, Quezon City University can showcase its commitment to sustainability and innovation, providing a practical and eco-friendly solution for the campus community.

Incorporating innovative technology, the project focuses on converting foot traffic into sustainable energy. By utilizing piezoelectric transducers, the system efficiently captures the mechanical energy generated by people walking and transforms it into electrical energy. This technology ensures that every step taken

on designated walkways contributes to the overall power supply of the charging station. This approach not only provides an eco-friendly solution but also promotes awareness of renewable energy sources within the campus.

Additionally, the integration of RFID and data visualization enhances the efficiency and security of the system. RFID technology allows for easy tracking of power usage, ensuring that students can conveniently access the charging station while maintaining organized monitoring. Meanwhile, data visualization provides real-time insights into energy generation and consumption, allowing administrators to analyze and optimize power distribution. By implementing these features, the project aims to deliver an efficient power generation system that maximizes sustainability and usability for the QCU community.

1.2 Background of the Study

Quezon City University (QCU), located in Quezon City, Philippines, was established in 1994 as Quezon City Polytechnic University (QCPU). The university's mission has always been to provide accessible and quality education, especially in technical and vocational fields. In 2019, QCPU was renamed Quezon City University through Republic Act No. 10931, a move that reflects the institution's commitment to enhancing academic standards and research capabilities. Today, QCU offers a wide range of undergraduate programs in engineering, information technology, business, and entrepreneurship, all designed to equip students with both technical skills and professional expertise.

As part of its ongoing efforts to improve student life, QCU fosters an environment where students are encouraged to develop innovative solutions that benefit the entire campus community. One such initiative is the POWERWALK project, an innovative idea created by student researchers at QCU. This project aims to provide students with a convenient and accessible way to charge their mobile devices while on campus.

In today's digital era, access to reliable power sources for charging electronic devices is a necessity, especially in educational institutions where students rely heavily on smartphones, tablets, and laptops for academic and administrative tasks. Charging stations have become increasingly common in large establishments such as malls, government offices, schools, and convenience stores, addressing the growing demand for accessible and convenient power sources. However, many of these charging stations rely on conventional electricity, contributing to increased energy consumption and higher operational costs.

The POWERWALK project uses piezoelectric transducers installed in busy walkways across the campus to capture the energy generated by footsteps. These transducers are special devices that turn pressure or movement into electricity. Every time someone steps on the walkway, the pressure from their foot creates a small electric charge. This energy is stored and used to power mobile charging stations in high-traffic areas, providing students with a free and convenient way to charge their phones when they need it most. In addition, the project incorporates Radio Frequency Identification (RFID) technology, where students will use their official school ID to start the charging process. By simply tapping their ID on a scanner, students can activate the charging station and begin powering their mobile devices.

By combining simple, everyday activities with innovative technology, the POWERWALK project offers an alternative solution that directly benefits the entire university community. It demonstrates how small changes can improve student experiences and make daily tasks more convenient.

To address this challenge, the integration of piezoelectric sensors presents innovative solutions. These sensors convert mechanical energy from foot traffic into electrical energy, harnessing kinetic energy that would otherwise go to waste. By strategically placing these sensors in high-foot-traffic areas within the university, this project aims to generate renewable electricity to power a charging station, promoting energy efficiency and sustainability within the campus. The Powerwalk project falls on some of the 17 Sustainable Development Goals criteria which are, SDG 7 "Affordable and Clean Energy" The project generates electricity using piezoelectric tiles, promoting sustainable and innovative energy solutions. By harnessing kinetic energy from foot traffic, it contributes to eco-friendly power generation. Another is SDG 9 "Industry, Innovation, and Infrastructure" The use of Arduino Uno with RFID and smart charging technology represents an innovative infrastructure solution. It demonstrates how technology can improve urban energy efficiency. It also falls in SDG 11 "Sustainable Cities and Communities" By providing an innovative charging station, the project supports green energy solutions in urban areas like Quezon City University. It encourages

sustainable habits and enhances public infrastructure. And lastly the SDG 12 "The project reduces dependency on traditional electricity sources, promoting energy efficiency and responsible consumption. It also encourages the use of renewable energy in daily life."

Furthermore, the Power Walk system incorporates RFID (Radio Frequency Identification) technology for seamless and secure access. The RFID system allows students to use their university ID cards to activate the charging station, ensuring controlled usage and preventing unauthorized access. Additionally, the system integrates data analytics to monitor energy generation and consumption, providing valuable insights into usage patterns and optimizing efficiency.

By combining an alternative energy generation with smart technology, this project aligns with global efforts toward sustainable development and green energy solutions. It not only enhances the university's infrastructure but also fosters awareness and adoption of renewable energy technologies among the students Ultimately, this initiative contributes to a more environmentally friendly, cost-effective, and innovative approach to powering devices within academic institutions.

1.3 Objective of the Study

General Objective

The main objective of the capstone project is to develop "POWERWALK": Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation.

Specific Objectives

The objectives of the study are specifically as follows:

1. To identify the purpose for which the proponents are developing a mobile charging station for the QCU campus in San Bartolome.
2. To develop a system that can monitor and track Energy generation and Consumption of battery and report real-time energy usage in the system and is connected to a local network server.
3. To develop an eco-friendly charging station hardware device, that will help students of QCU to have easy access when in need of a charging station, in case of emergency and sudden draining of personal phones, without the restrictions of the school Policy.

4. To develop a hardware device that serves as a charging station powered by, harvesting foot traffic from people going in the institution, by converting kinetic energy into mechanical energy, from the Piezo Tile.
5. To develop a system that is Simple to use, that uses Arduino Technology to Authorize students when using their RFID card, to create a hassle-free charging process with just a tap of their Official School ID.
6. To develop a hardware device that can accommodate various type of charging connectors.
7. To deploy a capstone project in high-traffic areas of Quezon City University, such as entrances to assess its effectiveness in generating energy through foot traffic, tracking usage via RFID, and collecting real-time data to support the university's sustainability efforts.
8. To determine the respondent's level of agreement using ISO/IEC 25010 Software Quality model, based on the following criteria:

    6.1 Performance Efficiency;
    6.2 Security;
    6.3 Usability;
    6.4 Compatibility;
    6.5 Reliability;
    6.6 Maintainability;
    6.7 Functional Suitability;
    6.8 Portability.

1.4 Significance of the Study

This study focuses on addressing a common issue at Quezon City University: students are not allowed to charge their mobile phones on campus. The research aims to solve this problem by developing a charging station powered by mechanical energy generated from foot traffic, using piezoelectric transducers. The following will be benefited by the system.

To the Students of QCU

This study is significant as it directly benefits the students of Quezon City University by addressing the issue of being restricted in charging of mobile devices on campus. With the development of a renewable energy-powered charging station, students can conveniently charge their mobile devices, ensuring uninterrupted access to educational resources and communication. And also, by showing how foot traffic may be transformed into useful energy, this project increases students' knowledge of sustainable energy practices. It serves as a practical example of how innovative technology can address real-world problems while promoting environmental responsibility.

To the Future Researchers

This study will help future researchers in further improving the system itself, when it comes to expanding the range of places/businesses powered by this renewable energy. And also, this would serve as a guide for them in implementing this type of system in barren places that are in need of electricity.

To The Community of QCU

This study benefits the community of the school as it provides service to the academics of QCU to have an emergency, portable charging station for students who are in need of charging, without the need of restricting school building policies.

1.5 Scope and Delimitations of the Project

Scope

1. The researchers have proposed a capstone project entitled ““POWERWALK”: Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for efficient power generation that will provide the students of QCU of San Bartolome Campus a charging station for their mobile devices.
2. The admin has access to all functionalities, including, receiving an email after successfully making an account, generated reports, the overall generated electricity consumption, chart of daily electricity consumption & generated battery percentage, voltage status, chart of daily usage of students using the Powerwalk charging station, and registration of RFID and records.
3. The Powerwalk charging station will be available to use, for students at Quezon City University San Bartolome Campus.
4. The Piezo tiles will convert kinetic energy from footsteps into mechanical energy, which will be stored in a battery and used to power the charging station for mobile devices.

5. The system will use Arduino uno to validate the student ID cards and use NODEMCU ESP 8266 technology to verify if students is registered in the system
6. The Piezo Tiles will be installed in high-foot traffic areas which are the entrance/gate within Quezon City University San Bartolome Campus, allowing the people to generate energy as they walk.
7. The Software's design will be direct and simple to follow, to allow the admins to easily understand the functionalities without needing too much expertise with the system.
8. The Powerwalk charging station will offer multiple charging wires (e.g., USB-A, USB-C, Lightning,) to accommodate different mobile devices and charging needs.
9. The Powerwalk charging station will allow students to charge for a limited time of 15 minutes a day.
10. The software will be deployed locally.
11. The System will prioritize the Functional Suitability, Performance Efficiency, Compatibility, Usability, 6.5 Security, Maintainability, and Portability that will be seen both in the student and admin side to assure

the functionalities and performance of the project will be aligned with the standard of the ISO/IEC 25010 Software Quality model

Limitation/Delimitation

1. The system installation will be limited to specific high-footfall areas within Quezon City University such as the entrance/gate and will not be deployed in other locations.
2. The system only allows students to charge in the powerwalk charging station.
3. The energy generated by footsteps will be restricted to low-power device charging, primarily mobile phones, and not for larger electronic devices or appliances.
4. If a student didn't finish the 15 minutes given time for charging, they are no longer able to charge again within that day, and if they didn't finish the 15 minutes given time, the timer of the charging station will not reset. Another student is only allowed if the 15 minutes is up.
5. The amount of energy stored in the battery will limit the duration and number of devices that can be charged at a time, especially during low-footfall periods.

6. The charging station can efficiently serve a limited number of users at a time, with optimal results when two or fewer devices are connected simultaneously.
7. The energy generated by the system will only be stored locally within its battery, and it will not feed into the university's electrical grid.
8. The system is not available online.
9. The Piezoelectric Tile should be installed on an area that is not prone to flooding.

1.6 Theoretical Framework

The Development of **"POWERWALK":** Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation is supported by the following theories:

Inertia Harvester Theory

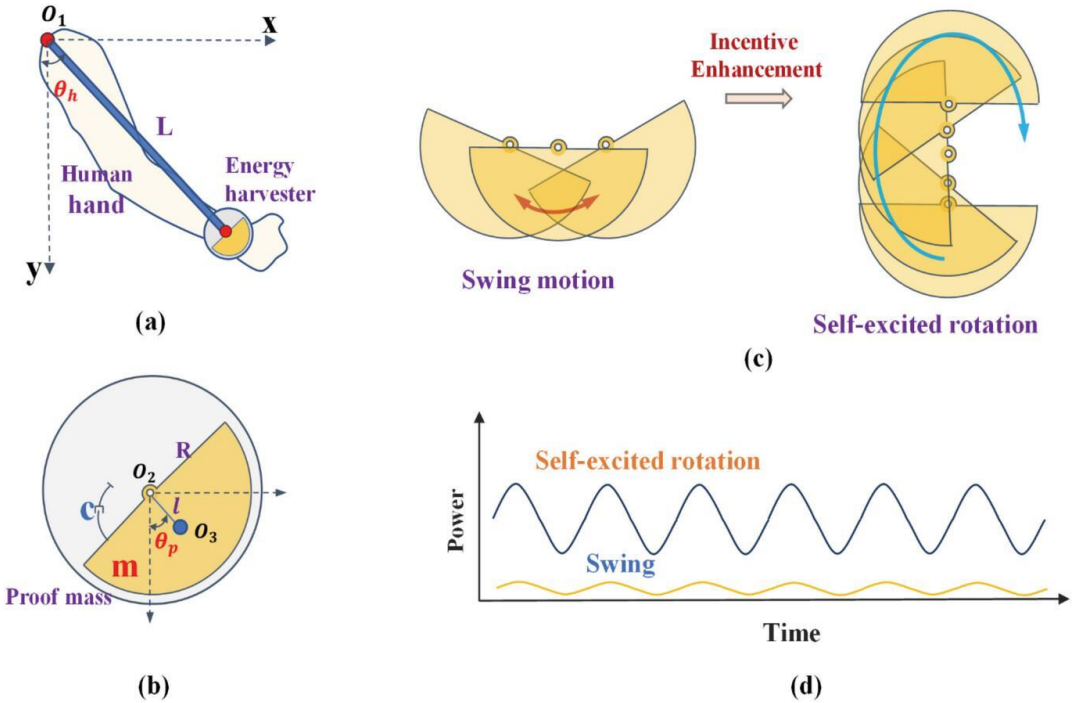


Figure 1.1 Inertia Harvester Theory, (Zhang et al. 2024)

The Inertia Harvester Theory explains how mechanical motion, particularly vibrations and impacts, can be converted into electrical energy using an inertial mass, a restoring force (such as a spring), and an energy transduction mechanism. When an external force, such as a footstep impact, is applied to the system, the proof mass moves relative to the structure, generating energy through mechanisms like piezoelectric, electromagnetic, triboelectric, or electrostatic

conversion. This theory is fundamental in the development of self-sustaining, low-power energy solutions for wearable electronics, smart infrastructure, and renewable energy applications.

Our capstone project, which focuses on harvesting energy from foot traffic, aligns directly with the Inertia Harvester Theory, as it involves converting mechanical energy from walking into usable electricity. By incorporating inertial harvesting principles, our system can efficiently capture and store energy generated by human motion, providing a sustainable and innovative solution for powering IoT devices, smart buildings, or public infrastructure. This connection underscores the feasibility, efficiency, and real-world impact of our project in advancing clean energy technologies.

Dielectric Theory

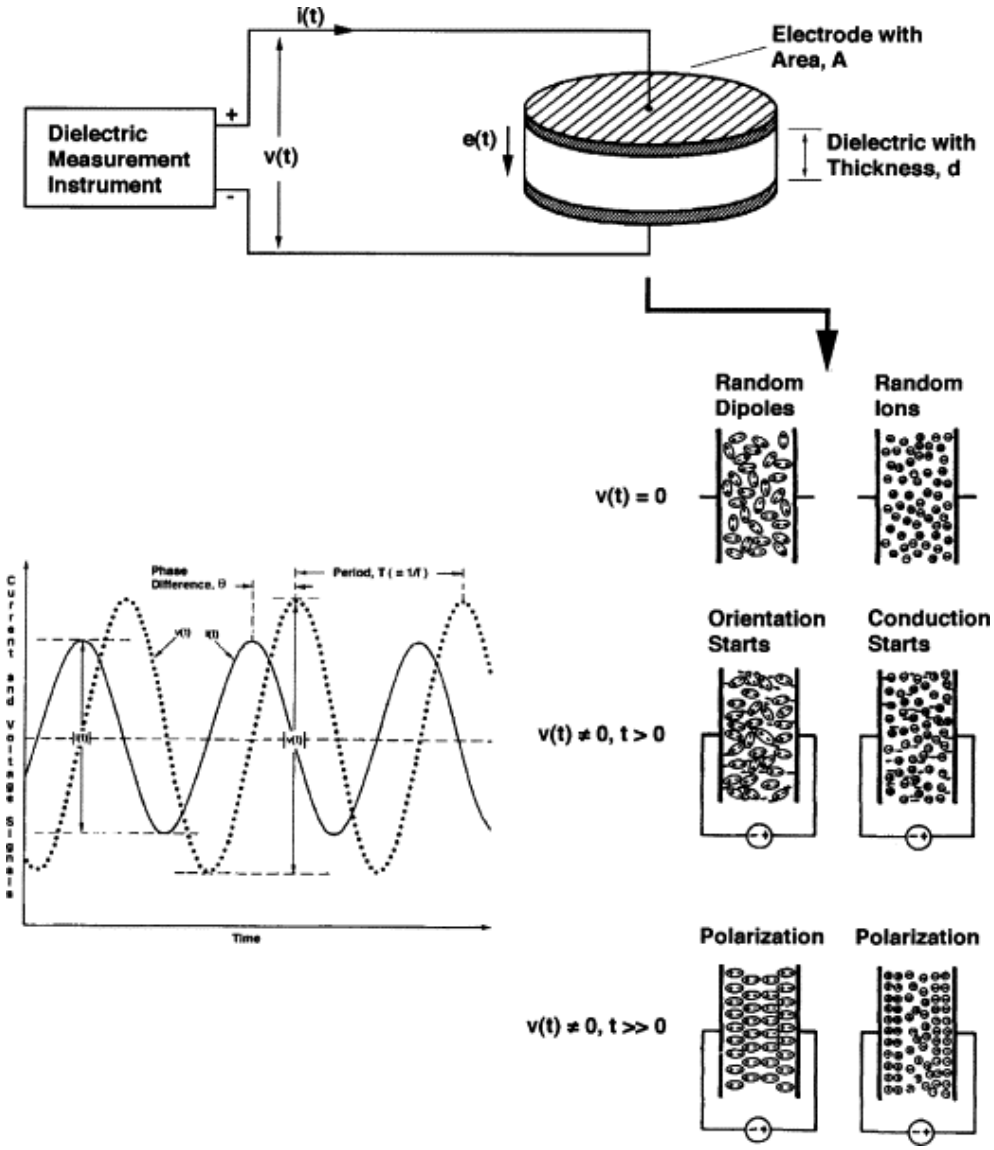


Figure 1.2 Dielectric Theory, (Kolesar 2001)

Dielectric Theory explains how certain materials, called dielectrics, respond to an electric field by storing energy instead of conducting electricity. When an electric field is applied, the positive and negative charges inside the material shift slightly, creating polarization. This helps the material hold electric charge, which is why dielectrics are used in things like capacitors, sensors, and insulation for electrical devices.

Our project on footstep energy harvesting relates to Dielectric Theory because some energy-harvesting systems—like triboelectric generators—use dielectric materials to collect and store electric charge from movement. By choosing the right dielectric materials, we can improve energy storage and efficiency, making our system more effective in converting footsteps into usable electricity.

Piezoelectricity Theory

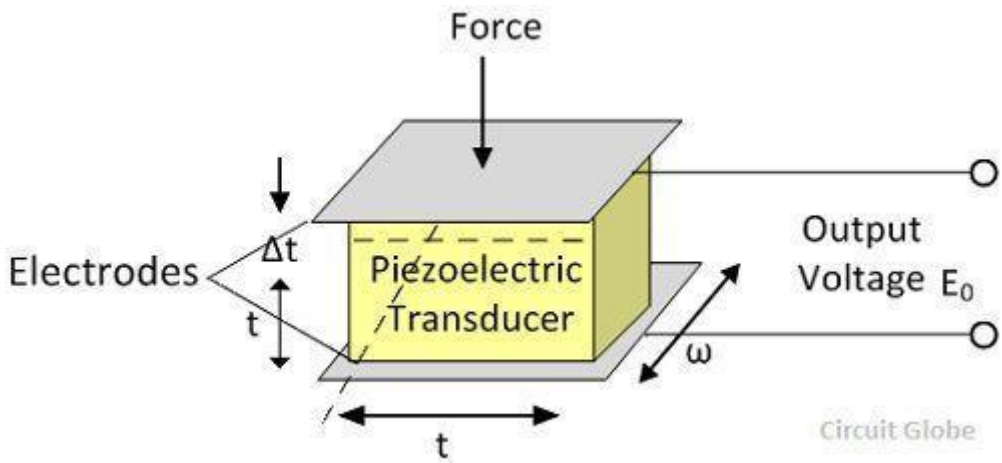


Figure 1.3 Piezoelectricity Theory, (YOGESHWARAN 2018)

The Theory of Piezoelectricity describes how certain materials can generate an electric charge when subjected to mechanical stress. This effect occurs in piezoelectric materials, such as quartz, ceramics, and some polymers, which have a unique crystal structure that lacks a center of symmetry. When pressure or vibration is applied, the internal charges shift, creating an electric potential. This process is reversible, meaning that applying an electric field can also cause the material to deform.

This Theory relates to our footstep energy harvesting project because it helps describe how materials deform and recover under repeated foot traffic. If our

system uses flexible or viscoelastic materials (like rubber, gels, or soft polymers), understanding their elastic and viscous behavior will help optimize energy conversion efficiency. By selecting materials with the right viscoelastic properties, we can improve how effectively our system captures and transfers mechanical energy into electrical energy.

1.7 Conceptual Framework

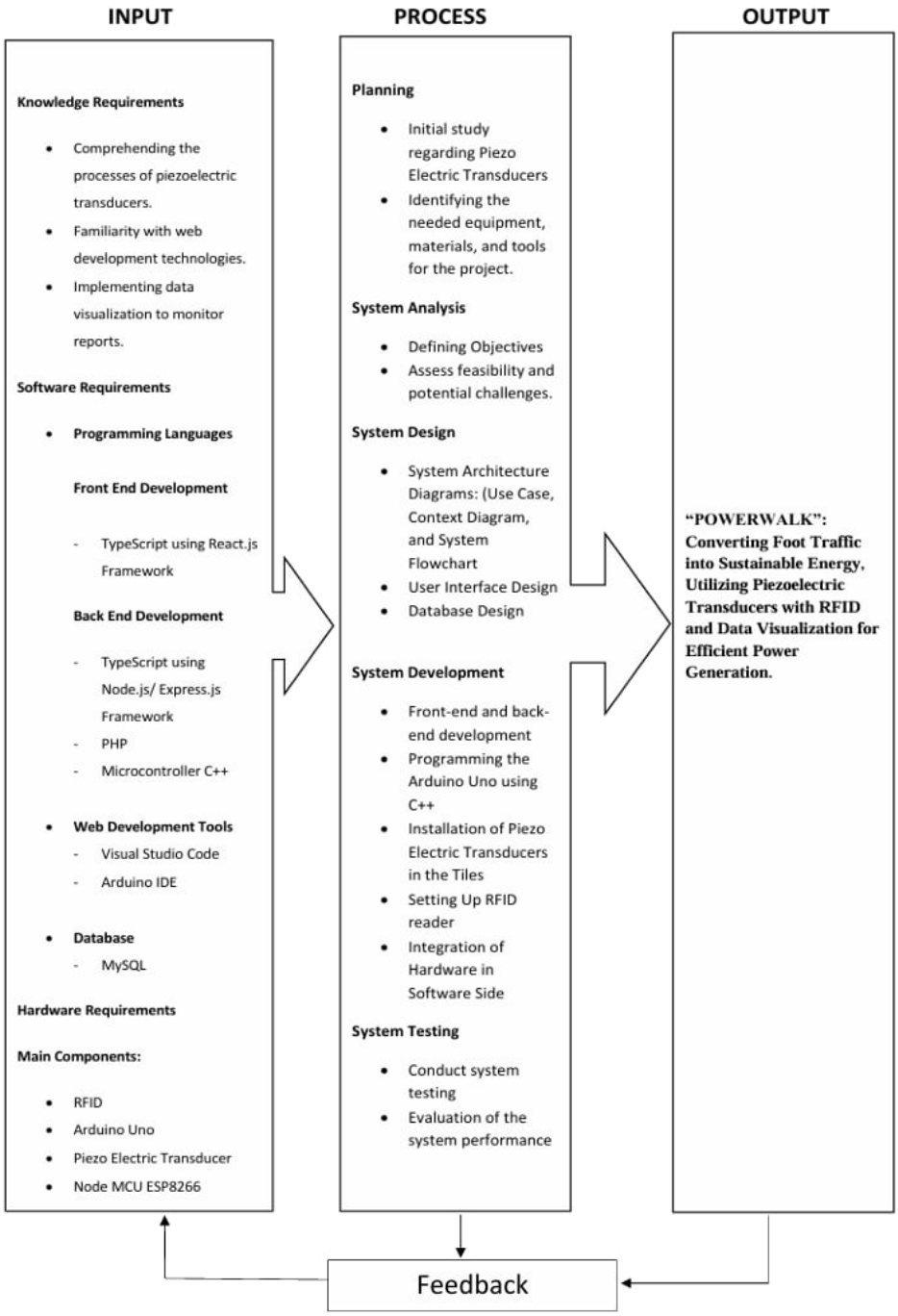


Figure 1.4 Conceptual Framework

The Input-Process-Output (IPO) model serves as the conceptual framework for "Power Walk": Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation. It provides a structured view of how the system transforms gathered resources into a working product. The inputs involve understanding the piezoelectric technology, being familiar with essential software and hardware tools, and knowing how each component contributes to the system. These elements serve as the foundation for building and programming the system, allowing the team to effectively manage each part of the development.

During the process, these inputs are put into action through research, design, and integration. The hardware is assembled and connected with the software to ensure smooth communication and energy conversion. RFID technology helps identify users and manage access, while data visualization allows the monitoring of system usage and energy generation. The final output is a working charging station that uses foot traffic as a sustainable energy source. Feedback from the system is also looped back into the process, helping improve performance and ensuring the system remains efficient and reliable over time.

1.8 Definition of Terms

Arduino – Arduino is an open-source microcontroller platform used to build and program electronic projects. It's like a brain for your DIY gadgets, making coding and prototyping simple and accessible.

Data – Data refers to raw facts and figures collected from observations or measurements. It forms the foundation for analysis, helping to turn information into knowledge.

Mechanical Energy – Mechanical energy is the energy of an object due to its motion or position. It can be either kinetic energy (energy of motion) or potential energy (stored energy of position).

NodeMCUESP8266 – It can be used as a standalone device, or as a UART to Wi-Fi adaptor to allow other microcontrollers to connect to a Wi-Fi network.

Kinetic Energy – Kinetic energy is the energy an object possesses due to its motion. The faster it moves, the more energy it has, like a speeding car or a spinning windmill.

Piezoelectric Plates – Piezoelectric plates are special materials that generate electrical energy when subjected to mechanical pressure.

They are commonly used in devices to convert physical force into useful electrical signals.

Piezoelectric Transducers – A device that converts mechanical energy into electrical energy, or vice versa. They are often used as sensors or actuators.

POWERWALK Charging Station – A portable charging station designed for the students of Quezon City University at San Bartolome Campus.

Real - Time Reports – The system will report in real-time every time a student/admin will tap on the charging station's RFID.

RFID (Radio Frequency Identification) – RFID is a wireless system that uses radio waves to identify and track objects through small tags. It's like a digital ID card that works without touch, making processes like inventory management efficient.

CHAPTER 2

REVIEW OF RELATED LITERATURE STUDIES

Related Literature and Studies

2.1 Foreign Literature

Sukanya, K., Prashanth, A., Sravani, R., Vienala, S., Gangadhar, J., & Ugendhar, A. (2024) investigated the potential for producing power from human foot movement. Their study focused on transforming the physical energy expended during walking into electrical energy using piezoelectric materials. This idea is highly relevant in densely populated areas such as train stations and temples, where continuous movement occurs. The proposed system integrates piezoelectric sensors into flooring, converting foot pressure into electrical energy, which is stored in batteries for later use. An RFID module secures the energy, allowing authorized users to access stored power for charging electronic devices like smartphones.

This study is directly related to our system as both focus on harvesting energy from foot traffic in public spaces. By utilizing piezoelectric technology, our system also aims to convert wasted kinetic energy into usable electricity.

Similar to the approach taken by the authors, our system involves using sensors for energy capture, an Arduino Uno for processing, and RFID technology to secure access, making it a practical solution for energy generation on university campuses.

Ganesh and Sharmila (2019) examined the voltage-to-current (V-I) characteristics of different piezoelectric materials, specifically Polyvinylidene Difluoride (PVDF) and Lead Zirconate Titanate (PZT). Their findings indicate that PZT is the more efficient material due to its higher output voltage and current generation capacity. Prior studies confirm that PZT is a preferred material for energy harvesting due to its high electromechanical coupling coefficient and stability under varying pressure conditions (Shen et al., 2017).

This study is closely connected to our system. Like the reviewed research, our system utilizes piezoelectric transducers to convert mechanical stress from foot traffic into electrical energy. By selecting efficient materials like PZT, we ensure optimized energy conversion and storage.

Ingale, K., Jivtode, A., Bandgar, S., Biyani, A., & Chaware, V. (2023, April) investigated a system that converts energy from human footsteps into electrical power using piezoelectric materials. The generated energy is stored in a battery and used to charge mobile devices through RFID technology.

This study aligns closely with our project, as both systems leverage piezoelectric sensors to capture kinetic energy from footsteps. Similar to the reviewed study, our system incorporates an Arduino Uno for processing and an RFID system for secure access, ensuring efficient management and usage of stored energy.

Hans, D., Gandhar, S., Aggarwal, A., Batra, I., & Singh, K. H. (2022) explored the potential of harnessing energy from vibrations caused by human activity, focusing on integrating piezoelectric materials for energy generation. The study highlights the growing need for alternative energy sources and methods to increase energy efficiency. Specifically, it discusses the integration of piezoelectric sensors with smart street and traffic lights as a sustainable energy solution for power-deficient areas.

This study is relevant to our project since both systems aim to harness energy from human activity using piezoelectric technology. While the reviewed study focuses on smart street lights and traffic signals, our system applies a similar concept by capturing energy from foot traffic on campus, promoting sustainability.

Bhatele, P., Mali, S., Mali, A., Chrungoo, M., Mali, A., & Makode, R. (2022) proposed a system where piezoelectric sensors are embedded in the soles of shoes

to convert mechanical energy from footsteps into electrical energy. This energy is stored in a battery within the shoe and can be used to charge mobile devices via a USB port. This system presents an innovative approach to mobile charging using footstep-generated power.

This study is related to our system, as both capture foot traffic energy to convert it into usable electricity. However, while the reviewed study integrates piezoelectric sensors into shoes, our project applies them in public spaces such as university walkways to contribute to campus energy needs. Both systems promote sustainability through energy harvesting technologies.

Smith & Jones (2020) emphasize the importance of data visualization in energy management. Graphical representations of power generation, consumption trends, and user contributions improve awareness and encourage sustainable behavior. Brown et al. (2021) further highlight that implementing dashboards or mobile applications for real-time energy tracking increases public engagement and optimizes power distribution.

This study is related to our system because data visualization plays a crucial role in monitoring and optimizing energy usage. Since our project involves energy management, incorporating real-time graphical representations of power generation and consumption will enhance user awareness. By implementing

dashboards or mobile applications, similar to what Brown et al. (2021) suggest, users can track energy usage efficiently, leading to informed decisions that promote sustainability. This aligns with our goal of creating an interactive and user-friendly platform for energy monitoring.

Garcia & Lee (2019) discuss how universities worldwide are adopting renewable energy solutions to reduce their carbon footprint. Institutions implementing kinetic energy harvesting technologies have experienced reduced electricity consumption, supporting sustainability goals. Williams et al. (2022) highlight similar projects in educational settings, showing how foot traffic energy systems serve both as a power source and an educational tool for students.

This study is relevant to our system as it highlights the importance of renewable energy in academic institutions. Our project focuses on kinetic energy harvesting, which aligns with Garcia & Lee's (2019) findings on how universities use such technologies to lower electricity consumption. Williams et al. (2022) further support this by showing how foot traffic energy systems serve as both a power source and an educational tool. This is directly related to our system, as we aim to integrate kinetic energy solutions in a way that both contributes to sustainable energy and educates users on its benefits.

Zhang, H., & Zhu, S. (2023) conducted a comprehensive review of piezoelectric footwear energy harvesters (PFEHs), summarizing popular piezoelectric materials and their properties for energy harvesting applications.

This study is relevant to our system as it provides insights into the materials and designs that can be applied to harvest energy from foot traffic, similar to our project's objectives.

APC International, Ltd. (2023) discussed the application of piezoelectric tiles in public spaces to harvest energy from pedestrian movements. They highlighted the potential of these tiles to function as self-powered sensors for tracking foot traffic.

This study relates to our system as it explores the use of piezoelectric materials embedded in flooring to capture energy from foot traffic, aligning with our project's aim to implement similar technology on university campuses.

Li, X., & Strezov, V. (2023) summarized the current state of road energy harvesting technology, emphasizing piezoelectric systems and their potential applications.

This study is pertinent to our project as it provides an overview of advancements in piezoelectric energy harvesting, which can inform the development of our system.

Kumar, A., & Sharma, R. (2023) investigated the implantation of piezoelectric sensors beneath shoes to harvest electricity from vibrations produced by human movement, storing the energy in supercapacitors for later use.

This study is related to our system as it explores the feasibility of capturing energy from foot traffic, similar to our project's objectives.

Singh, P., & Verma, S. (2024) demonstrated a floor tile excited by human footsteps designed to generate usable electrical power using piezoelectric patches.

This study aligns with our project as it explores the use of piezoelectric materials in flooring to harvest energy from foot traffic.

California Energy Commission (2023) reported on the design of a piezoelectric energy harvesting system achieving an electrical energy density of 333 watts per square foot, aimed at harvesting high-density energy from roadways.

This study is relevant to our system as it explores high-density energy harvesting using piezoelectric materials, which could inform the design of our project.

Mishra, S., & Gupta, R. (2023) compared different technologies for converting walking energy to electricity, identifying piezoelectric materials as an effective method for energy harvesting.

This study is pertinent to our project as it evaluates the effectiveness of piezoelectric materials in harvesting energy from walking, aligning with our system's objectives.

Ma, D., Lan, G., Xu, W., Hassan, M., & Hu, W. (2020) proposed a system that uses a piezoelectric energy harvester to simultaneously generate electricity and recognize human gait patterns.

This study relates to our system as it explores the dual functionality of piezoelectric harvesters in energy generation and movement recognition, which could enhance our project's capabilities.

Isse, A. (2018) investigated a hybridized pyro-piezoelectric ferrofluidic harvester designed to capture energy from ambient vibrations and temperature fluctuations, utilizing piezoelectric materials to charge an integrated ultracapacitor.

This study is relevant to our project as it explores innovative approaches to energy harvesting using piezoelectric materials, which could inform the development of our system.

The Wikipedia article on piezoelectricity provides an overview of the piezoelectric effect, materials exhibiting this property, and various applications, including energy harvesting from mechanical stress.

This resource is pertinent to our project as it offers foundational knowledge on piezoelectric materials and their applications in energy harvesting, informing the technical aspects of our system.

Li, X., & Strezov, V. (2018) examined the potential application of a commercial piezoelectric energy harvester in a central hub building at Macquarie University in Sydney, Australia, optimizing tile deployment based on pedestrian mobility.

This study relates to our system as it provides a model for implementing piezoelectric energy harvesting in educational institutions, similar to our project's objectives.

2.2 Review of Local Literature

"Energy Generation through Footsteps Using Piezoelectric Sensors" The study cited is comparable to the developer's method, which harvests energy by walking into piezoelectric plates. The developers are also looking at transforming footstep energy into power for a charging station at the university's entrance. This study aims to provide free electricity for university students, professors, and visitors. These findings highlight the need of exploiting human actions for sustainable energy generation, which will be useful in the design of energy

harvesting footprint from people who go down the stairs using piezoelectric sensors. *(Avestruz et al (2024)*

"Using RFID, a student is required to login in the system on a daily basis. The scanning of the ID is a must because it indicates students' data in the system." The study mentioned above has the same functionality as the researchers' studies. The proposed study involves using RFID to authenticate the student's credentials in order to receive a free charge for their mobile devices. The RFID's function is to tap in order to access the charging station, which will show on screen with a limited period for students to charge their mobile devices for free. The project intends to assist students in providing a daily free charge for them mobile devices, as well as the institution in conserving energy. *(Mojares, P. V. (2019).*

"The use of Arduino as microcontroller supported designers makes their implementation easier." This research is comparable to a developer's system. The researcher uses the Arduino to regulate the time and cut the energy. The Arduino's goal is to program and control the flow of data in the development system. The study's goal is to investigate the extent to which students see and experience new technologies used in Embedded Systems. *(Dasig, D. D. (2019)*

"The energy derived from piezoelectric sensors are only a few of these advancements offered by our present technology". The research initiatives mentioned above are equivalent to the researchers' studies. This research aims to give an alternative source of energy through vibration or direct contact with piezo plates. Footfall energy is a unique energy source that can power low-energy density devices capable of transporting small loads, such as a charging station. Kinetic energy increases when the footstep makes contact with the tile, eventually reaching the terminal velocity. *(Adenio, V. M. et al. (2019)*

"The objective of our research is to create a hybrid solar and wind renewable energy. Used as a source of electrical power to supply a charging station will be implemented in High Education institutions." The referenced studies are comparable to the developer system. Free charging station that harvests energy from the footstep using piezo plates. This pricing will be free for university students, professors, and guests. This project intends to provide free energy to students who need to charge their mobile devices at the specified time. This project aims to implement energy-saving measures by using the kinetic energy generated by footsteps. *(Ytis, M. A. et al. (2021).*

In the study titled Piezoelectric Energy Harvesting Flooring, the researchers explored the conversion of wasted foot energy into electricity. They highlighted that the average person takes around 3,000 to 5,000 footsteps daily, which can

generate sufficient force to convert into electrical energy using piezoelectric crystals. This study is connected to our system as it demonstrates the feasibility of harnessing foot traffic to generate energy, a core concept in our system's design. Just as the study emphasizes the use of piezoelectric technology for sustainable energy, our system leverages similar principles for power generation and further innovation in energy harvesting. *(Pamintuan et al. (2023)*

In the study titled Energy Generating-Steps: Piezoelectric Transducers as a Source of Electric Power, explored a piezoelectric transducer setup designed to capture energy from foot traffic in high-density areas. Their system utilized bridge diode rectifiers, fiberglass boards, and conductive graphite sheets to transform mechanical pressure into electrical energy. The study revealed that energy output varied with individual weight, achieving a peak output of 25.13V with heavier individuals. This study directly relates to our system, because its aim is to capture energy from foot traffic in public spaces. By employing similar piezoelectric principles and emphasizing structural stability, our system builds upon these findings to implement a scalable and efficient energy harvesting solution for high-traffic university areas. *(Catapang, Garcia Jr., Comia, Cruz, and Azul (2019)*

In the study, they developed a footstep generator for energy harvesting in two shopping centers in Surigao City. Titled Footstep Generator for Energy Harvesting in Commercial Spaces, the study utilized a wood-tile type 3x2ft module embedded

with parallel piezoelectric elements at a main entrance. Using a microcontroller to regulate the voltage, the researchers achieved an average power output of 668.5 mW over 12 hours, with potential scalability to 2W for mobile phone charging. This study is relevant to our system, as it demonstrates the practical application of piezoelectric modules in public areas and reinforces the potential of generating significant power in high-foot-traffic locations. The insights gained from their modular setup and output efficiency inform the design of our system which seeks to maximize harvested energy in an educational campus setting. *(Bacarro, Ylaya, Vicerra, and Delante (2021)*

In the study, they investigated the potential of footsteps as an energy source in their study Scalable Electricity Generator for Off-grid Application using Pressure Plate Tiles as Electrical Energy Harvester. This study focused on converting kinetic energy from footsteps into electrical energy for powering low-voltage devices. Their prototype employed a translation-to-rotation mechanism with 12V generators in series and a Footstep to Electricity (FTE) Charge Controller with supercapacitors and an MPPT module, achieving a maximum output of 2.98W from a single footstep. The system demonstrated the ability to power low-power devices, such as a 1W LED, for extended periods. This study is relevant to our system as it exemplifies a scalable, efficient solution for energy harvesting from

footsteps, aiming to support off-grid applications through compact and efficient energy storage and control systems. The technological insights and efficiency metrics contribute valuable design and efficiency considerations for implementing our own piezoelectric-based energy harvesting platform. *(Arellano, Bodegas, Nakpil, Marcella, and Sueno (2022)*

In the study, they conducted research to address the global demand for energy resources and the environmental impact of fossil fuels. Their study, Energy Harvesting Stairs Using Piezoelectric Sensors as a Sustainable Energy Source, emphasizes the importance of alternative, sustainable energy sources, with a focus on piezoelectric materials as a viable solution. By designing energy-harvesting stairs, the researchers demonstrated the potential for sustainable development while reducing reliance on fossil fuels. This study is pertinent to our system as it highlights the growing need for renewable energy sources and supports the role of piezoelectric technology in meeting that demand. The insights into sustainable energy generation reinforce the environmental and practical benefits of our project, which seeks to provide a renewable energy solution for university campuses. *(Avestruz, Dalisay, Lavada, and Pile (2024)*

According to the researchers' piezoelectric sensors were integrated into pedestrian crosswalks to convert mechanical energy from footsteps into electrical

energy. The project also analyzed pedestrian behavior to optimize urban energy solutions and demonstrated the potential of combining renewable energy with behavioral studies.

This study provides insights into how energy harvesting can be effectively implemented in public spaces with significant foot traffic. It also underscores the dual functionality of piezoelectric systems in energy generation and behavioral analysis, both crucial for developing sustainable energy infrastructure in institutions. *(De La Salle University-Dasmariñas (2020)*

According to the RFID-Based Student Attendance Monitoring System at Bestlink College of the Philippines integrates RFID with SMS notifications and Arduino technology. The system aims to automate attendance tracking and provide real-time updates to parents and school staff via text messages. Researchers highlighted its efficiency in improving security and communication between the institution and stakeholders through the seamless use of technology. *(Nueva et al. (2024)*

This study showcases the potential of RFID technology in accurately capturing and communicating attendance data. In the context of my research, this underscores the practicality of RFID systems not only for tracking attendance but also for monitoring foot traffic in environments like universities. By leveraging

RFID's ability to generate real-time data, its integration into energy-harvesting systems could enhance the accuracy and reliability of traffic-based energy conversion metrics.

According to the researchers, Project SPARTA was launched to enhance data analytics expertise nationwide. The program offers structured pathways for professionals and students to gain advanced skills in analyzing and utilizing large-scale data, particularly in energy and transportation sectors. *(Development Academy of the Philippines (2023)*

This initiative highlights the importance of data analytics in optimizing systems for sustainability. Incorporating these analytics into energy harvesting projects can help predict trends, improve efficiency, and ensure the optimal use of harvested energy in urban infrastructures.

According to researchers, the V2X initiative at the University of the Philippines utilized IoT and AI to enhance communication between vehicles and infrastructure. This system improved traffic flow, road safety, and energy efficiency, demonstrating the potential of smart technologies in urban environments. *(Castor (2023).*

The V2X initiative illustrates how IoT frameworks can be adapted to enhance piezoelectric systems in urban areas. Its focus on real-time communication and

system optimization aligns with the integration of energy harvesting technologies in public spaces.

According to the Philippine Council for Industry, Energy, and Emerging Technology Research (2023), IoT-enabled e-trikes with piezoelectric systems were developed to generate sustainable energy and collect real-time data. The project emphasized reducing environmental impact through innovative transportation solutions.

This study highlights the effectiveness of combining energy harvesting with IoT, offering a model for applying similar methods in urban areas with heavy foot traffic. Such integration can improve sustainability and system performance for renewable energy projects.

The researchers present the design and development of a web-based attendance and class scheduling system that utilizes RFID technology in combination with Raspberry Pi hardware. The system is designed to automate attendance tracking in educational institutions by using RFID tags attached to students and faculty members. The Raspberry Pi acts as a central processing unit, facilitating data collection and real-time updates to the scheduling system. *(Reyes and Caras (2021)*

The authors discuss the system's architecture, emphasizing the integration of RFID with web-based platforms for efficient attendance management. They also address the potential for scalability and future improvements, such as the inclusion of energy harvesting technologies like piezoelectric systems to power the system. This research highlights the use of RFID technology in improving administrative tasks and explores opportunities for incorporating sustainable energy solutions in smart educational environments.

The researchers conduct a feasibility study on the integration of a piezoelectric power generator into a bicycle to harvest energy from pedaling. The study explores how piezoelectric materials can be used to generate electricity while cycling, making it a potentially sustainable energy source for powering small devices or charging electronic equipment.

The authors discuss the design and implementation of the piezoelectric generator on a bicycle, considering factors such as energy output, efficiency, and practicality. The study concludes that piezoelectric power generation through pedaling has significant potential for energy harvesting, particularly in areas with high cycling traffic. This research offers valuable insights into the future of personal energy generation, combining mobility with sustainability. *(Bombio, De La Serna, and Tappa Jr. (2022)*

The researchers investigate the potential of using piezoelectric technology at pedestrian crossings to generate sustainable energy from foot traffic. The study focuses on the feasibility and impact of integrating piezoelectric generators into pedestrian infrastructure, aiming to produce electricity for streetlights and other urban amenities. (*Mariano, Santos, and Cruz (2021)*

The research also examines how the installation of piezoelectric systems at pedestrian crossings can influence pedestrian behavior, particularly in terms of encouraging more mindful walking to maximize energy generation. The study concludes that piezoelectric pedestrian crossings can contribute to sustainable energy solutions and may also lead to changes in pedestrian habits, fostering a more energy-conscious public.

The researchers explore the potential for harvesting human energy using piezoelectric materials in the high-foot traffic environment of Metro Manila train stations. The study investigates the installation of piezoelectric sensors on train station floors to capture the mechanical energy generated by the movement of commuters. *(Villanueva and Ramirez (2022)*

The research evaluates the efficiency of piezoelectric systems in such public spaces and considers the feasibility of using the generated energy to power lighting, ticketing systems, and other station utilities. The authors conclude that

implementing piezoelectric energy harvesters in public transportation hubs could significantly contribute to sustainable energy practices in urban environments

The researchers analyze the impact of piezoelectric energy generation on urban communities, focusing on the potential for integrating piezoelectric systems into existing urban infrastructure. The study examines how energy harvesting from foot traffic, public transportation, and other human activities can contribute to powering various urban services such as streetlights, sensors, and public charging stations. *Garcia and Bautista (2021)*

The authors assess the social, economic, and environmental benefits of implementing piezoelectric technology in urban spaces, concluding that it can contribute to sustainability by reducing reliance on conventional energy sources. The study also discusses the challenges of scalability and the need for public policy support to encourage widespread adoption.

According to Abigail N. Gonzales, E., & B. Muyot, D. N. (2022). "Locally available materials were used in constructing the prototype which was equipped with a solar energy harvesting system and sunlight tracking system using Arduino uno to program the sunlight tracking module" There are parallels between their

system and ours. They are similar to our energy source. The sole distinction is that we use piezoelectric sensors, whereas others use sunlight. When linked to the relay module, which is in charge of cutting the charging station's current flow, the Arduino Uno is also in charge of tracking the data. With the Arduino IDE, users may create and upload code to the Arduino Uno, enabling a variety of creative and adaptable behaviors for robotics, home automation, and other embedded systems applications. Both novice and expert makers favor it because of its ease of use and adaptability.

2.3 Synthesis of the Reviewed Literature and Studies

The studies presented provide a foundation for understanding the potential and practical applications of piezoelectric energy harvesting systems, offering insights into the development of "PowerWalk." These systems are consistently centered on transforming mechanical energy from human or environmental movements into electrical energy, aligning directly with the goals of "PowerWalk," which seeks to harness foot traffic at Quezon City University to generate sustainable power.

The studies collectively emphasize the potential of piezoelectric technology as a sustainable solution for energy generation by harnessing kinetic energy from

human foot traffic and other mechanical sources. Research such as Sukanya et al. (2024) and Ingale et al. (2023) highlights systems where piezoelectric sensors embedded in flooring capture energy from footsteps, convert it into electricity, and store it in batteries for later use. These systems often integrate RFID technology to secure access and manage energy usage, making them practical for high-traffic public spaces like train stations, temples, and campuses. Similarly, Hans et al. (2022) and Ganesh et al. (2021) explore the application of piezoelectric sensors in public infrastructure, such as traffic lights and LED systems, demonstrating their versatility and scalability for urban settings.

Other studies focus on advancing the efficiency and adaptability of piezoelectric systems. Research by Sezer and Koç (2021) and Sharma et al. (2022) delves into the material properties and design optimizations of piezoelectric tiles, exploring ways to maximize energy harvesting efficiency in urban and pedestrian-heavy environments. Kiran et al. (2024) and Bhatele et al. (2022) extend these concepts by proposing innovative applications, such as embedding sensors in shoes or stairways, further broadening the scope of kinetic energy harvesting for powering low-demand devices. Collectively, these works emphasize the importance of clean energy solutions that minimize environmental impact and address the growing demand for renewable energy.

These findings are directly relevant to the development of "Powerwalk," a system designed to convert foot traffic into sustainable energy using piezoelectric transducers, RFID technology, and data visualization at Quezon City University.

By adapting the principles and methodologies from these studies, "Powerwalk" aims to create an efficient energy harvesting system tailored for university walkways. The integration of advanced piezoelectric materials, secure RFID modules, and smart data visualizations will enable the campus to harness and manage energy effectively, contributing to sustainability and promoting the practical use of renewable energy sources in academic institutions.

Even though a lot of studies talk about piezoelectric energy harvesting, there are still some gaps that PowerWalk is here to fix. Most research focuses on using this tech in places like train stations, roads, and malls, but not much has been done in universities. That's a missed opportunity since campuses have tons of foot traffic that could be turned into energy. On top of that, while studies mention storing power in batteries, they don't really focus on how to manage or distribute it efficiently. That's where PowerWalk comes in with an RFID system to make sure energy is used fairly and doesn't get wasted. Another issue? Most studies don't include real-time energy tracking, so users have no idea how much power is being generated or used. PowerWalk fixes this by adding dashboards and data

visualization, making it easy for students and staff to see how their footsteps are powering the system.

There's also the question of long-term durability. While studies agree that PZT is the best piezoelectric material, not much research has been done on how well it holds up in high-foot-traffic areas like a university walkway. Plus, while some research mentions hybrid energy solutions, not many explore mixing piezoelectric with other renewables like solar power. PowerWalk leaves room for that in the future, making the system even more efficient. Bottom line? A lot of research has been done, but PowerWalk takes it to the next level by making it practical, efficient, and accessible for university use.

CHAPTER 3

DESIGN AND METHODOLOGY

This chapter outlines the methodologies and technical approaches employed in the development of the **"POWERWALK":** Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation system. It explores the research methodology, data gathering techniques, requirement analysis and documentation, hardware and software development, system requirement modeling, project development cost, testing and optimization phases, and the implementation plan. By leveraging piezoelectric sensors, RFID technology, and data analytics, this study aims to efficiently convert foot traffic into sustainable energy at Quezon City University, ensuring an innovative and data-driven approach to energy harvesting.

3.1 Research Methodology

The Approach for this study is Quantitative Approach, to systematically collect and analyze numerical data. The research focuses on measuring the energy output generated from the foot traffic of students walk

across campus, utilizing piezoelectric sensors integrated with RFID technology and data analytics. By deploying Piezo tiles in high-traffic areas, the study aims to objectively evaluate the system's performance, energy conversion rates, and scalability. Statistical analysis will be used to identify patterns, relationships, and trends in the data, ensuring a data-driven and objective assessment of the system's feasibility.

This methodology aligns with existing research on piezoelectric energy harvesting, The study "Evaluation of Harvesting Energy from Pedestrians Using Piezoelectric Floor Tile Energy Harvester (Yingyong et al., 2021) " supports this research by demonstrating the effectiveness of piezoelectric floor tiles in converting foot traffic into electrical energy. Their findings showed that factors such as body weight and movement type significantly impact energy output, with heavier individuals and faster movement generating more power. By integrating findings from prior studies and implementing real-world data collection, this research ensures a data-driven evaluation of the system's feasibility, This approach allows for precise measurement and generalization of findings, contributing to the development of innovative and sustainable energy solutions.

3.2 System Development and Methodology

Agile Methodology

The proponents are using the Mixed Methods Approach along with Agile Methodology to make the development of POWERWALK flexible, step-by-step, and based on real data. Agile helps us divide the project into smaller tasks, allowing us to test, improve, and get feedback at each stage. This approach combines quantitative research, which focuses on measuring power output, RFID tracking accuracy, and foot traffic using numbers and statistics, with qualitative research, which gathers opinions and experiences through interviews, surveys, and feedback. By using both data and user insights, we can improve our piezoelectric energy system effectively, making it more reliable and useful for generating sustainable power at Quezon City University.

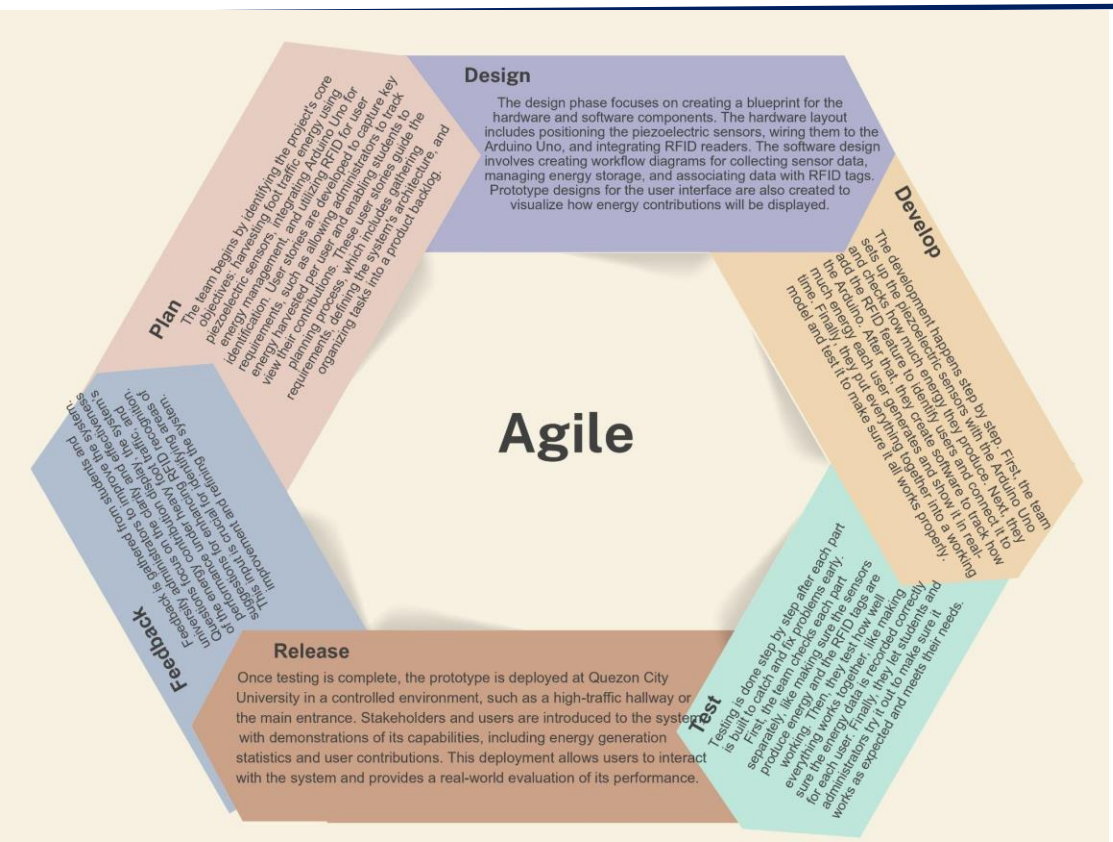


Figure 3.1 Agile Methodology

Planning Phase

The goal of the project was to develop a system that generates electricity from footsteps using Piezoelectric tiles. The system would include a battery for storing generated energy, a voltage sensor for monitoring power levels, a NodeMCU ESP8266 for wireless data transmission, an Arduino Uno for processing, an RFID

scanner for student registration, and an LCD module to display the remaining charging time. We also planned to integrate a relay module to regulate power distribution efficiently.

Design Phase

We focused on structuring the system for efficient energy capture, storage, and monitoring. The Piezoelectric tiles were positioned to maximize electricity generation, with the battery serving as the primary energy storage unit. The voltage sensor was placed between the battery and NodeMCU ESP8266 to enable real-time power level tracking. The NodeMCU then transmitted this data to the Arduino Uno, which controlled the LCD module for displaying charging time. The RFID scanner was integrated to register students, and a relay module was incorporated to manage power distribution.

Development Phase

We started by connecting the Piezoelectric tiles to the battery, ensuring proper energy storage. Then, we integrated a voltage sensor. The RFID scanner and LCD module were then added, allowing the system to track student usage and display the remaining charging time. A relay module was implemented to control power distribution efficiently. Finally, we programmed the system to monitor:

- Battery percentage and voltage levels
- Electricity generated and consumption
- Daily usage charts

Testing Phase

We tested each component individually:

- Piezoelectric tiles generated power and stored it in the battery.
- Voltage sensor correctly measured battery levels and transmitted data to the NodeMCU ESP8266.
- RFID scanner successfully registered students.
- LCD module displayed the correct remaining charging time.

Then, we conducted a full system test to ensure that the stored electricity could be used efficiently and that all components functioned correctly together.

Deployment Phase

The system was installed at the entrance of Quezon City University, where high foot traffic ensures continuous energy generation. Students scanned their RFID cards, walked on the Piezoelectric tiles to generate electricity, and the system

displayed their power contribution through battery status and remaining charging time.

Feedback Phase

After deployment, we collected feedback from students regarding ease of use, accuracy, and efficiency. Their input helped improve the system's power tracking and overall user experience.

3.3 Sampling Technique

In selecting the interviewees and participants in this study, the Proponents choose the people who are the main focus or users of this study. Students of Quezon City University will be the study's participants. These groups of people are chosen to be the participants of this study, because they are the ones who will ultimately benefit from this study. They are the ones who experienced the difficulty in finding places to charge while having drained phones inside the campus. By this, the participants are surely giving an impact in contributing to the studies further research and findings.

In the second semester of the academic year 2024–2025, the proponents employed convenience sampling to select students from all year levels at Quezon

City University (QCU) Main Campus and purposive sampling for administrative staff. The selection of participants was based on accessibility and relevance to the study.

A total of 371 students from QCU Main Campus were surveyed regarding their insights on the implementation of Power Walk, a charging station powered by piezoelectric tiles. Convenience sampling was utilized due to the ease of access to students who frequently use university facilities and are potential beneficiaries of the project.

Additionally, 5 administrative staff were selected through purposive sampling as they hold key roles in university facility management and energy consumption policies. Their input was deemed essential in assessing the feasibility and potential adoption of the Power Walk system within the university.

Sample Size Determination

The proponents used Cochran's formula to determine the appropriate sample size. This formula, developed by William G. Cochran, is widely used in research to calculate an optimal sample size when the total population is known. It provides a statistically valid number of respondents needed to achieve reliable

results while maintaining a specified level of precision. Given the large population of 10,915

students at QCU Main Campus, Cochran's formula was selected for its accuracy and efficiency in survey sampling.

The formula Is expressed as:

$$n_0 = \frac{Z^2 p(1-p)}{e^2}$$

Where:

- Z = (for 95% confidence level)
- p = (assumed proportion for maximum variability)
- e = (margin of error)

$$n_0 = \frac{[(1.96)^2 \text{ x}0.5\text{x } (1-0.5)]}{(0.05)^2}$$

Since the student population is finite, the sample size was adjusted using the finite population correction formula:

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

$$n = \frac{384}{1 + \frac{384 - 1}{10915}}$$

$$n = \frac{384}{1.0351} = 371$$

Thus, the final sample size for students was 371.

For administrative staff, 5 key personnel were selected using purposive sampling, ensuring that the respondents had direct knowledge and decision-making roles related to infrastructure, technology, and facility upgrades within QCU.

This approach allowed the researchers to gather valuable insights while ensuring the practicality of data collection for the study.

3.4 Data Gathering Technique

A. Observation

The proponents found problems about the mobile charging policy in the school, students aren't allowed to charge in the school buildings like the Academic building and the Techvoc buildings wherein there are students who frequently stay there for their assignments and studies. An observation was made when one of the Proponents was in the lobby of the Techvoc building, there were a lot of students using their laptops, ipads and their phones in the area. Coincidentally she needed a charging port because her phone gets drained easily. So, when she was looking for a charging port, she saw one near the table area, and she connected her charger. And just in a minute, a female guard asked her to remove her charger

because they would be scolded by the higher ups if they saw students charging their devices in the lobby.

B. Interview

The Proponents conducted an interview with the students, and staffs of Quezon City University, in order to understand more the purpose of the system to the school that the proponents are trying to assess. Before interviewing them, we asked if they were willing for a short interview with the compliance of The Republic Act 10173. We interviewed the Security guards during December 10, 2024 to ask when and what time there are masses of students and faculty coming in and out of the school. The 3 guards that we asked told us, mostly there are a lot of students during Mondays, and there are a few during Saturdays, they also added that there are always a lot of students coming in during the morning at exactly 7:00 onwards. So, from there, we targeted the students, with the schedule of 7:00am during Mondays. We were able to interview students from different courses entrepreneurship students near the entrance of the campus, and we asked them how many times their phones get drained? And they answered 1-2 times a day. We also asked them if they are aware that it is not allowed to charge inside the

school buildings like the Bautista and academic buildings, and to their surprise, it is the first time that they heard that it is not allowed to charge inside the rooms. And also, we asked them, if ever our System, the Power Walk would be officially implemented to the school after explaining the basic functions of the Powerwalk, would they use it? They answered that it would be efficient for the school to have such a system, so that the people who have phones that get easily drained would have a solution to their problem.

C. Evaluation Questionnaire

The Evaluation Questionnaire will serve as one of the crucial ways of assessing the satisfaction level and the overall performance and the quality of the Powerwalk Charging Station made for Quezon City University. Through this method the stakeholders, including the Properties, Supplies & Procurement Management Division and students, including, Performance Efficiency, Usability, Reliability, Security, Compatibility, Maintainability, Portability, Functional Stability. Participants were asked to rate theses aspects on a scale ranging from 1-5, with 5 pertaining Extremely Satisfied to 1 indicating Not Satisfied at all. The questionnaire allowed for a comprehensive evaluation of the system's

effectiveness in meter user requirements and their expectations. By gathering their direct insights from the users, the evaluation questionnaire provided valuable data and information for identifying strengths, areas for improvements for the researchers and also enhancements to ensure the system's optimal performance and user satisfaction.

3.5 Requirement Analysis and Documentation

The researchers gathered essential information through interviews and research. The key individuals involved include students, security guards, and administrators of Quezon City University. These individuals are involved in various functions such as evaluating its efficiency and usability, including enabling the charging of all mobile devices, such as iPhones and Android phones, determining the percentage of charge, a device can receive within 15 minutes, assessing the system's performance, and understanding the working principles of piezoelectric technology. The system focuses on harnessing foot traffic to generate electricity, which will be exclusively used for emergency purposes within the university. Currently, there is no existing system that provides an alternative energy source for such situations. The Power Walk System addresses this need by

offering a sustainable solution that converts footsteps into usable energy, ensuring a reliable backup power source during emergencies.

3.6 Software and Hardware Development Requirement

Table 3.1 Software Development Requirements

SOFTWARE	REQUIREMENTS
Programming Languages	TypeScript, PHP, C++, MySQL
Framework	React.js, Node.js, and TailwindCSS
Development Tools	Visual Studio Code, Arduino IDE
Libraries	React Query, Adafruit_BusIO, Adafruit_GFX_Library, Adafruit_SSD1305, Adafruit_SSD1306, LiquidCrystal_I2C, MFRC522
Database	MySQL
Browser	Google Chrome, Microsoft Edge, Brave

Table 3.2 Hardware Development Requirements

HARDWARE	REQUIREMENTS
Device	Laptop or Desktop
Operating System	At least Windows 10 or latest version of OS
Processor	At least Core i3, and AMD Ryzen 3
Memory	At least 4GB of RAM
Storage	256GB, or more.
Battery	12volts

Functional Requirements

User Authentication

• The user, specifically the admin, should confirm his/her email and password while setting up an account in the system.

• The admin has access to all features including RFID registration, monitoring of electricity consumption and generated per day.

Registration

• The student must register their ID to gain authorization for using the charging station.

Battery Percentage

• The software shall allow admin to monitor the battery percentage in the charging station

Electricity Generated

• The software shall allow admin to monitor the electricity generated from the piezoelectric tiles in real-time.

Electricity Consumption

• The software allow admin to monitor the electricity consumption in the charging station.

Daily Usage

• The software allow admin to monitor students who used the charging station per day.

Electricity Meter

• The software allow admin to monitor daily generated and consumption.

RFID

• The RFID shall verify a student's identity using RFID before granting access to the charging station. • The RFID shall check if the student is registered in the system before allowing them to charge their device.

• If a student has already used the charging station on a given day, the RFID will shall deny the ID to access.

Generation of Power

• The Piezoelectric Tiles should generate enough power to charge phones.

• The harvested power from the Piezoelectric will automatically store in the battery and automatically close if it reach it's limit by the help of the relay module.

Non-Functional Requirements

Performance

• The hardware should be durable and capable of withstanding continuous use in a student.

• The software should provide real-time updates on charging station status to enhance user experience.

Scalability

• The hardware should be designed to support the addition of more charging ports and piezoelectric tiles.

Reliability

• The software and hardware should ensure consistent and stable performance to provide uninterrupted charging services for students.

- The software and hardware should be designed to handle students simultaneously without failure or significant performance degradation.

3.7 Software/System Development Method

Table 3.3 Event Table

Event No.	Event Description	Date / Duration	Responsibility Party	Expected Outcome
1	Title Proposal	October 4, 2024	All Members	Approved Title Proposal
2	Requirements Gathering and Documentation (Chapters 1-3)	October 11, 2024 – December 10, 2024	Documentation Team	A comprehensive document outlining the project's context, methodology, and supporting information to establish a solid foundation for development.
3	System Design and Architecture	October 18-November 14, 2025	Documentation Team Programming Team	Detailed system architecture, design documents, and workflow diagrams.
	Software Development	November 8, 2024-		Functional software with

4	and Implementation	March 14, 2025	Programming Team	core features implemented.
5	Hardware Development and Testing	December 6, 2024- March 14, 2025	Hardware and Programming Team	Assembled and tested hardware components, ensuring integration with software.
6	System Testing and Debugging	December 6, 2024- March 14, 2025	Hardware and Programming Team	Identified and resolved bugs, ensuring system stability and efficiency.
7	Deployment and User Training	February 11- March 14, 2025	Hardware Team, Documentation Team	Successfully installed system, configured hardware and software, and ensured users are trained for smooth operation.
8	System Evaluation and Documentation Appendices	March 6-14, 2025	All Members	Comprehensive system report and documentation for future reference and improvements.
9	Project Review and Closing	March 2025	All Members	Finalized project review, addressed final feedback, and officially closed the68rojectt.

The table 3.3 contains the responsibilities for the development of "Power Walk": Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation. The project mainly begins with approval of the title and continues in the different phase requirements gathering, system design, development, testing, and deployment. Task are distributed among different teams like documentation, programming, and hardware teams to maximize the execution. Steps like debugging, evaluation are included to optimize system performance. The final stage focuses on project review and finalization of documents, ensuring the successful completion of the system by March 2025.

Research Method

The research method for this study is quantitative research to systematically collect and analyze numerical data. This study conducted an interview and observation for its Research method, which requires the proponents to collect data from the population through a designed questionnaire. This approach is fit for gathering information from a certain number of respondents, for it to be more accurate and reliable.

Data Collection

The data collection for this study is observation, interview, and Evaluation Questionnaire by using a constructed questionnaire. The purpose of this is to provide interaction and behaviors that can't be found in survey-questionnaire type of approach. This type of data collection allows the proponents to obtain certain information directly from the participants.

Ethical Considerations

The Proponents assure the participants that any information given and data are strictly confidential, for the proponents prioritize the safety of personal information of the participants so that it won't cause them any sort of harm, in compliance to the Republic Act 10173 – Data Privacy Act of 2012.

Population Sample and Participants

Sample of the Population

In this study, the proponent's targeted the students who have Monday schedules. A Total of 372 students of Quezon City University at San Bartolome Campus and 5 Staffs, who are allowed to enter the school premises with a Schedule of 7:00 am onwards during Monday.

The eligibility criteria:

The eligibility criteria in this study were that the participants must be:

- A Student of Quezon City University at San Bartolome Campus
- A Staff of Quezon City University at San Bartolome Campus

3.8 System Requirement Model

System Flowchart

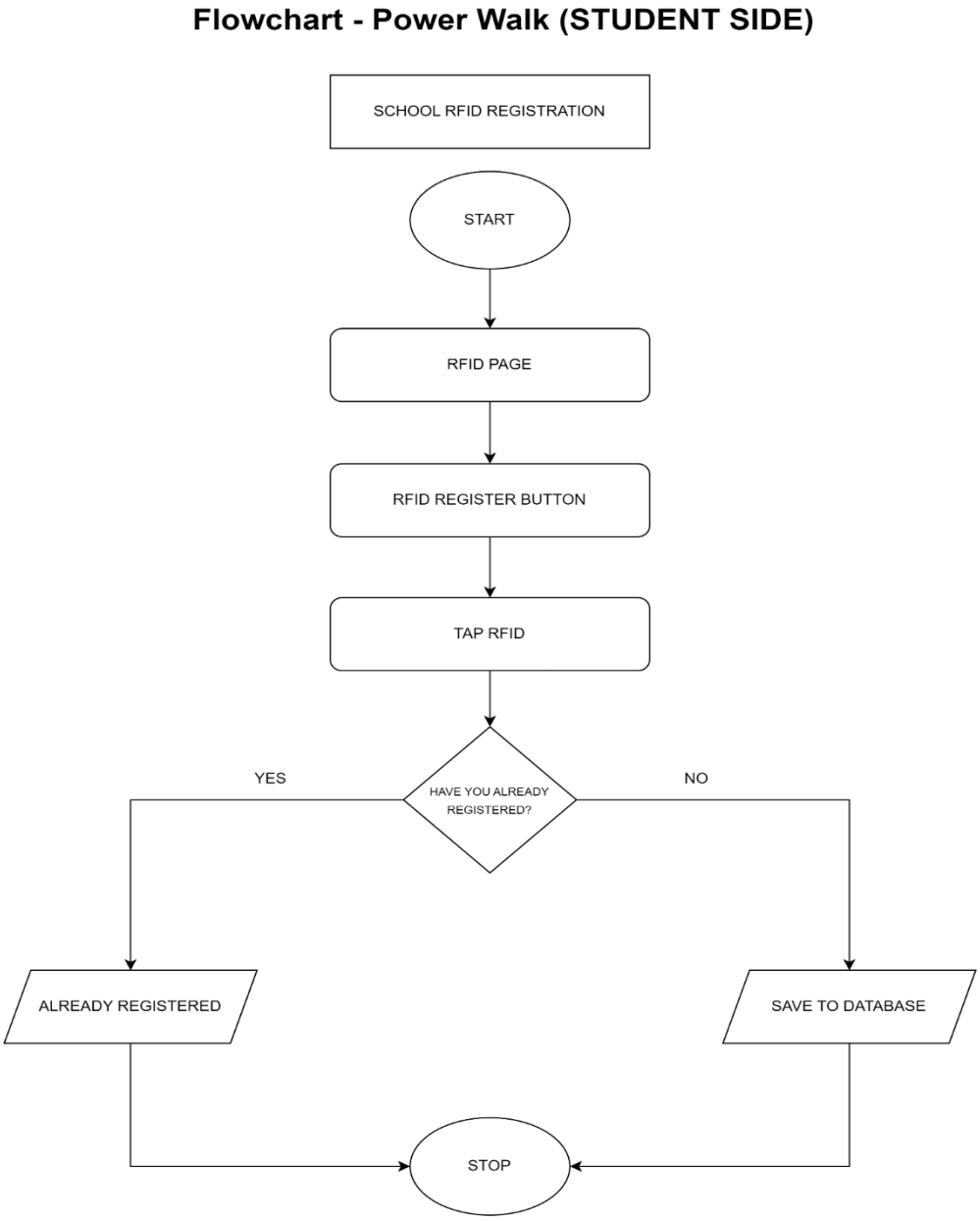


Figure 3.2 System Flowchart (Student Side)

Login

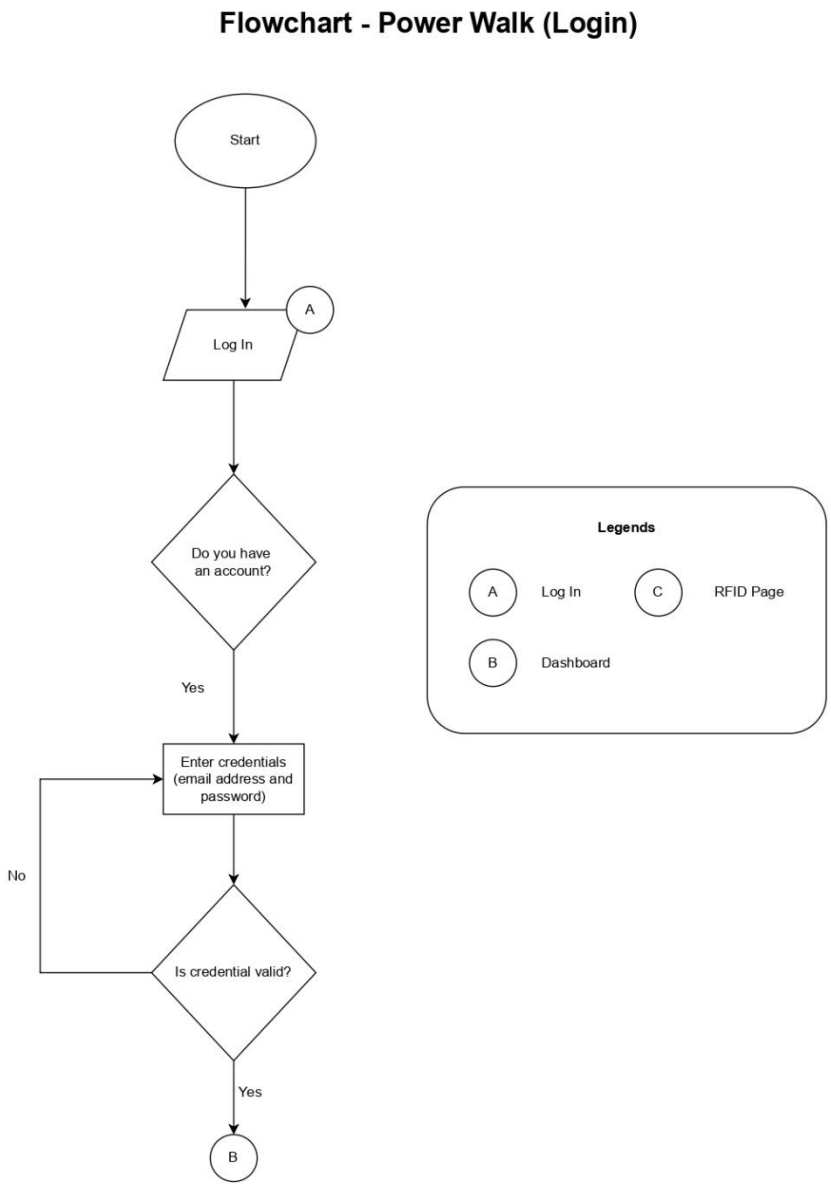


Figure 3.3 System Flowchart (Admin Log In)

Dashboard

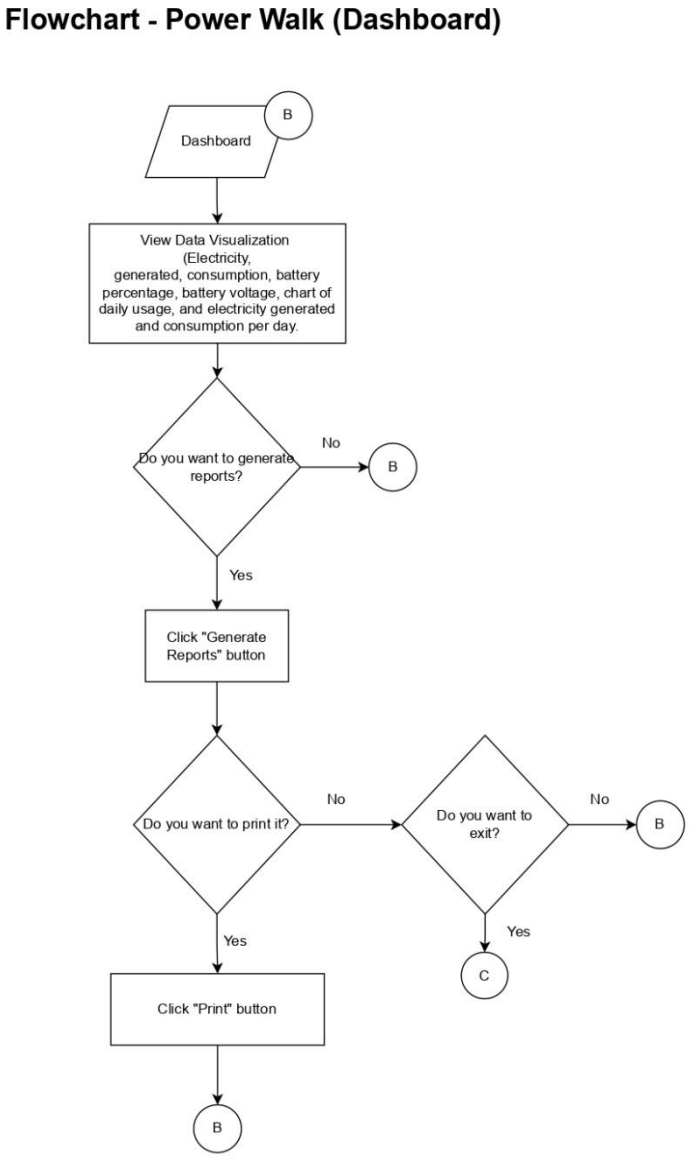


Figure 3.4 System Flowchart (Admin Dashboard)

RFID Register

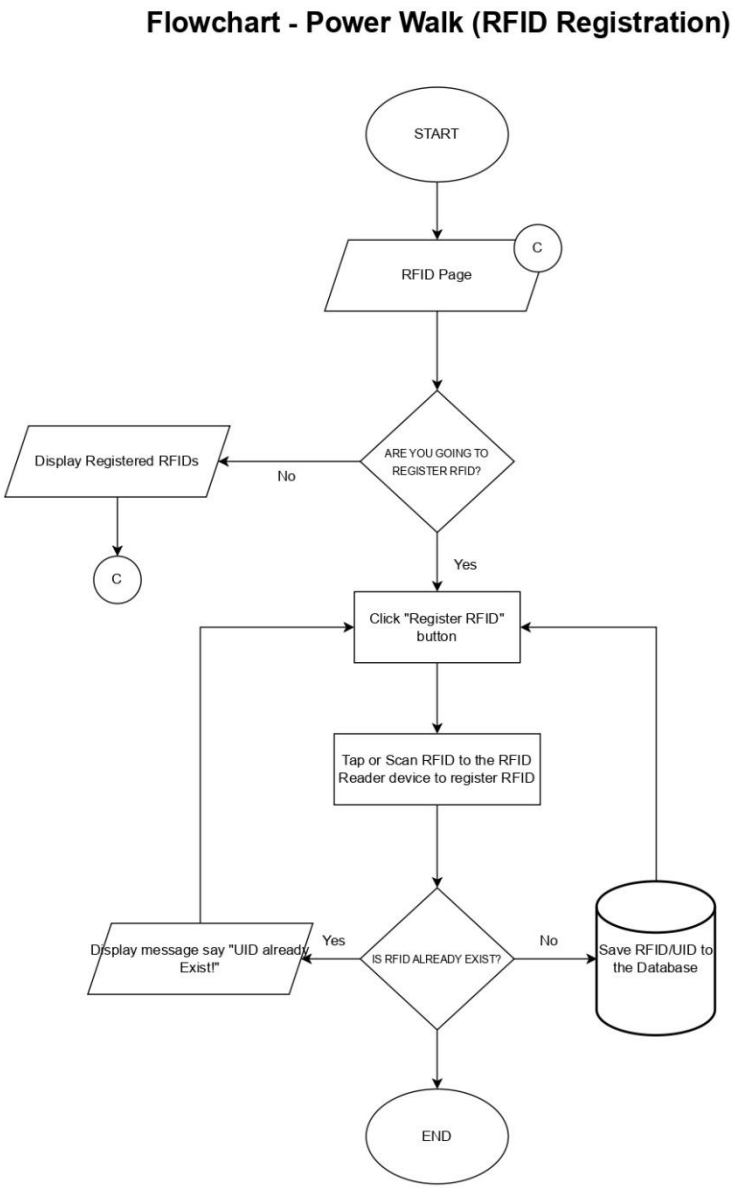


Figure 3.5 System Flowchart (RFID Register)

Context Diagram

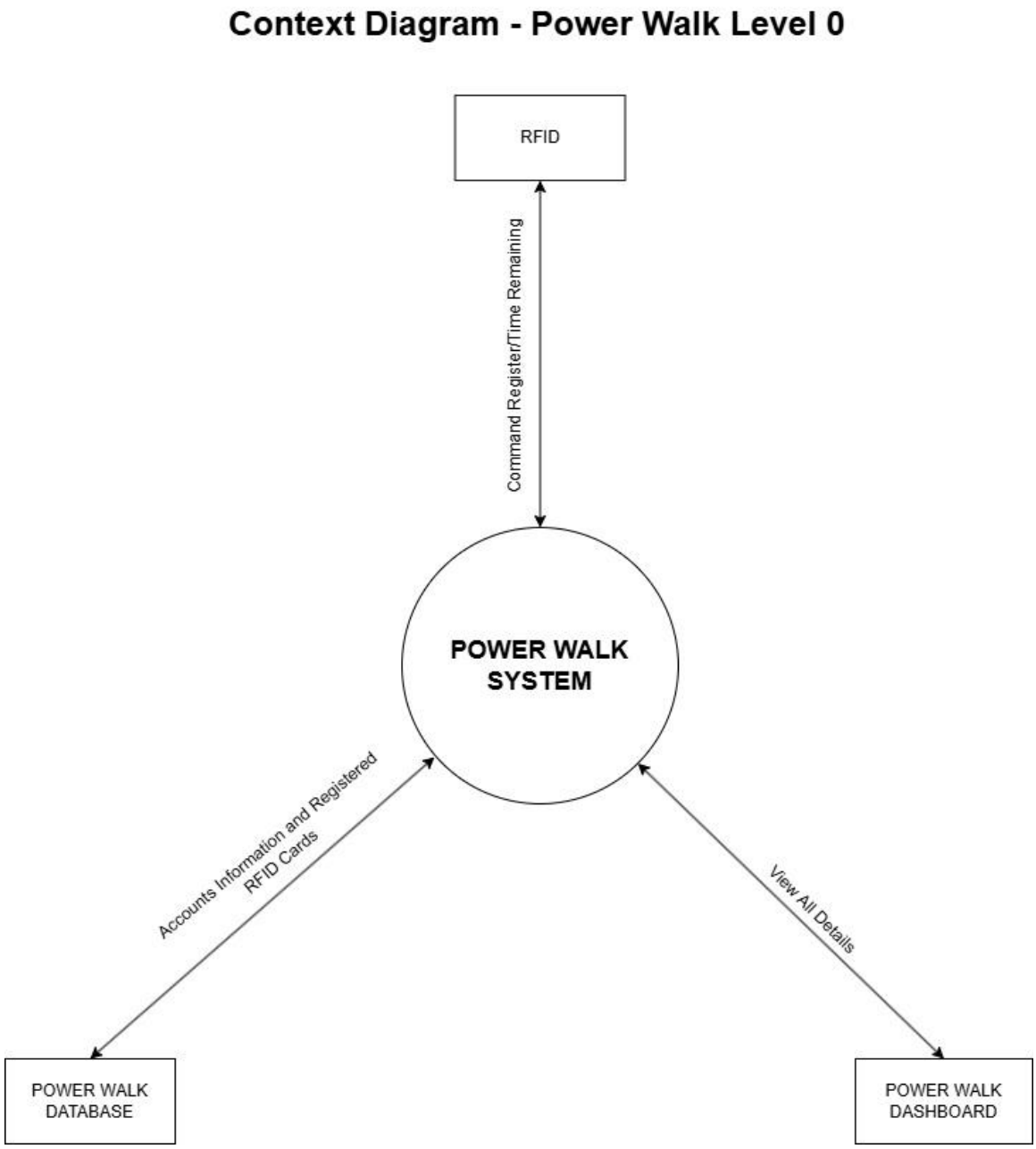


Figure 3.6 Context Diagram

Data Flow Diagram Level 1

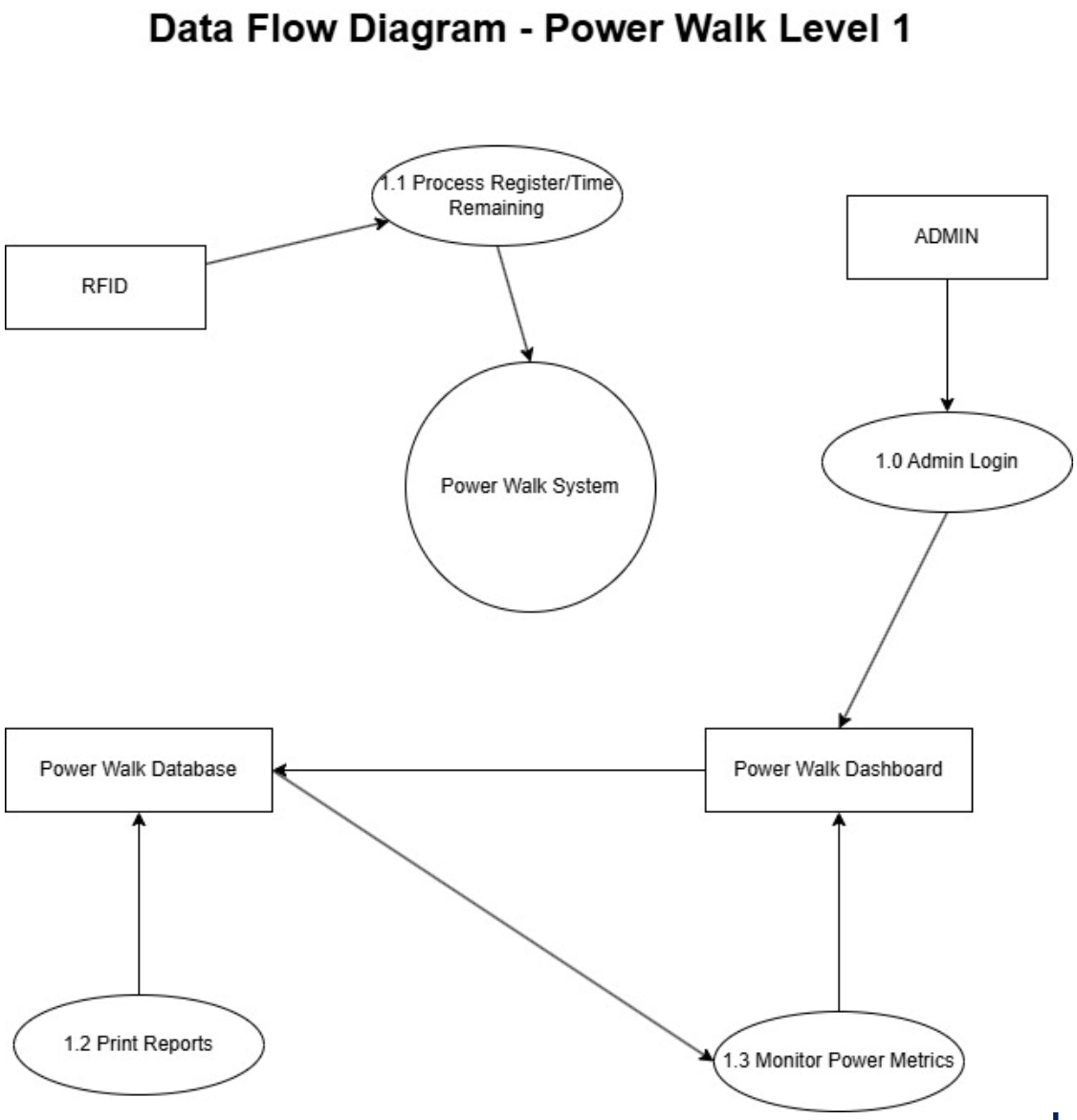


Figure 3.7 Data Flow Diagram – Level 1

Data Flow Diagram Level 2

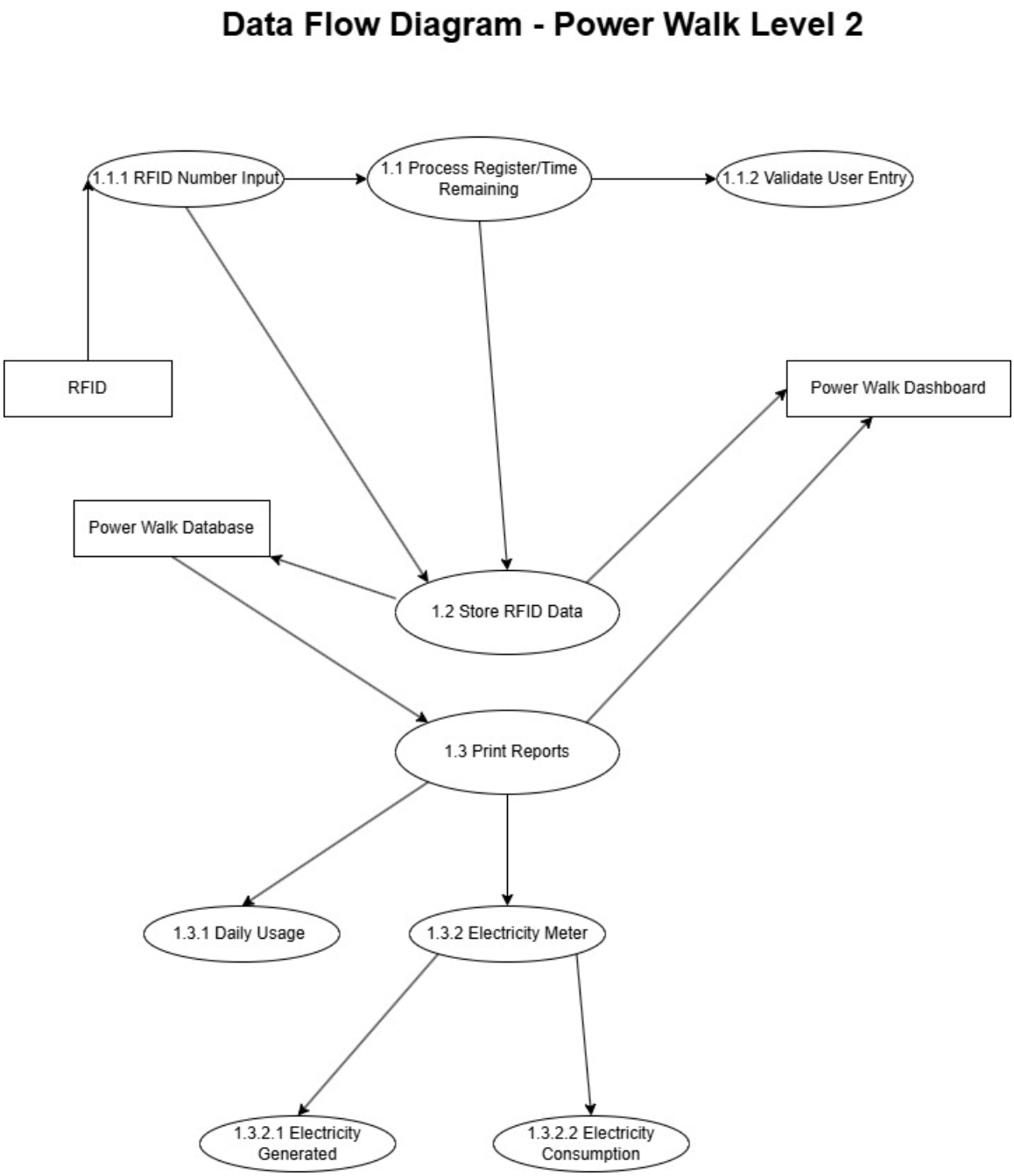


Figure 3.8 Data Flow Diagram – Level 2

Use Case Diagram

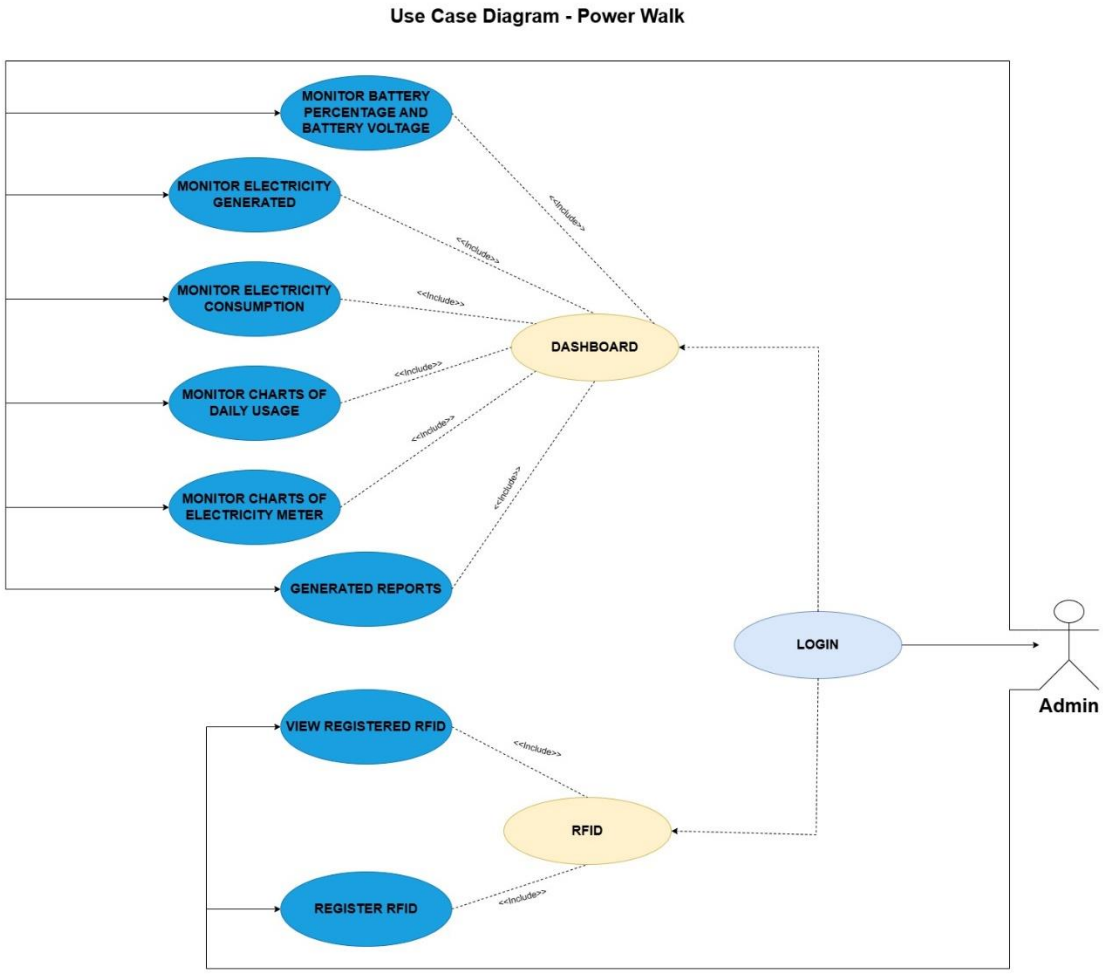


Figure 3.9 Use Case Diagram

Entity Relationship Model

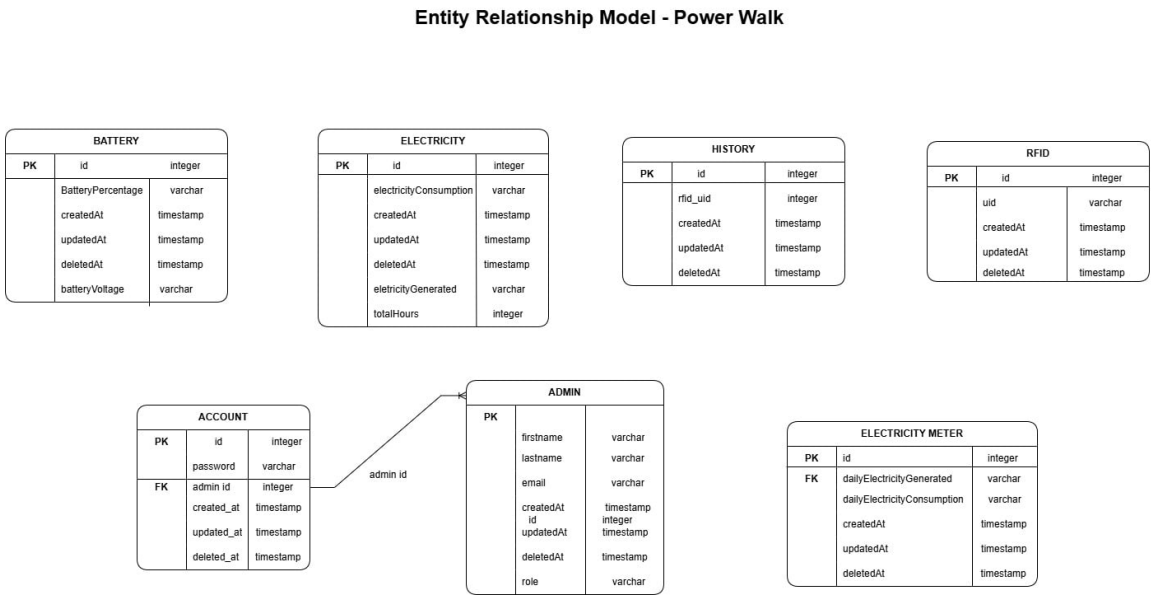


Figure 3.10 Entity Relationship Model

Hardware Prototype Blueprint

This is the Prototype of Hardware that shows the framework of the Charging Station. The device includes multiple components that are crucial for the development of the System's functionality.

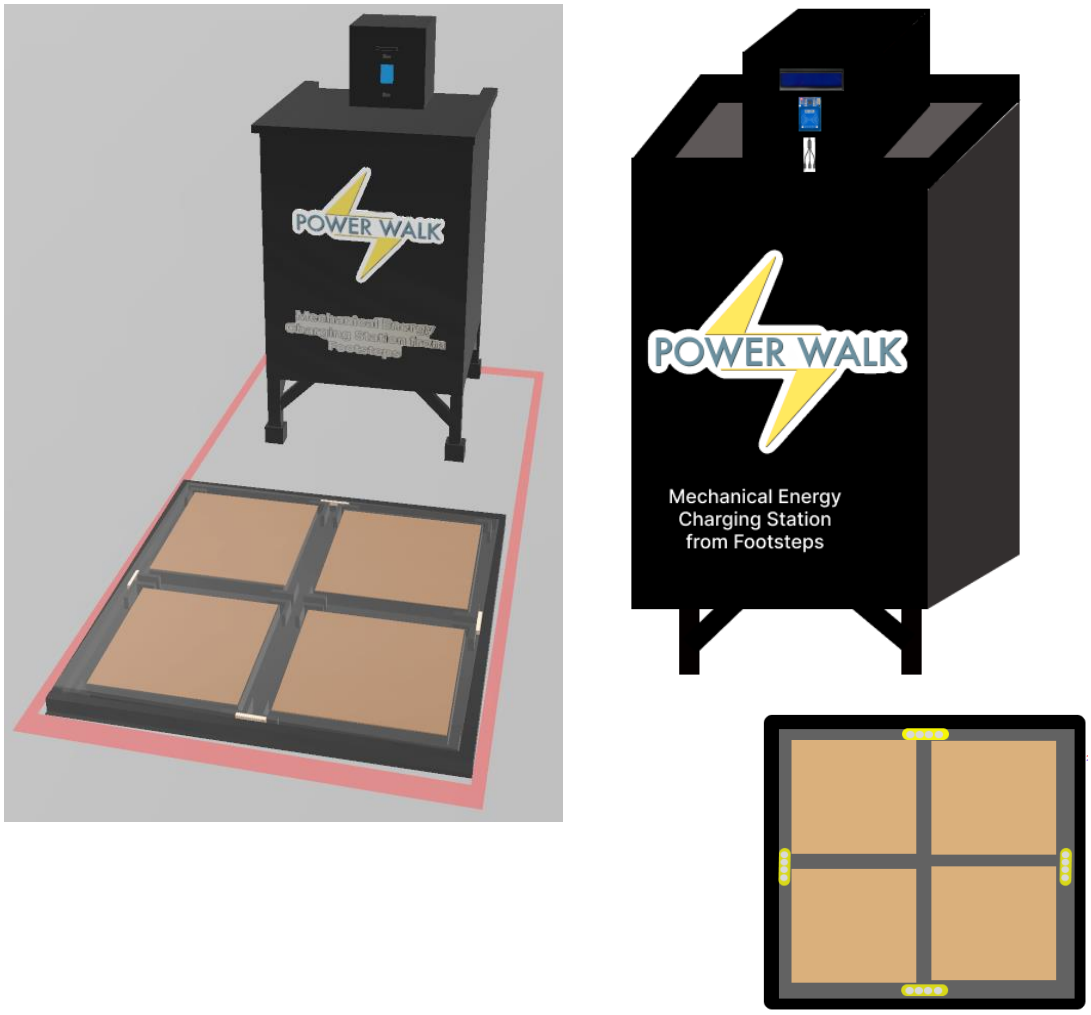


Figure 3.11 Hardware 3d and 2d Prototype

Top Box Prototype

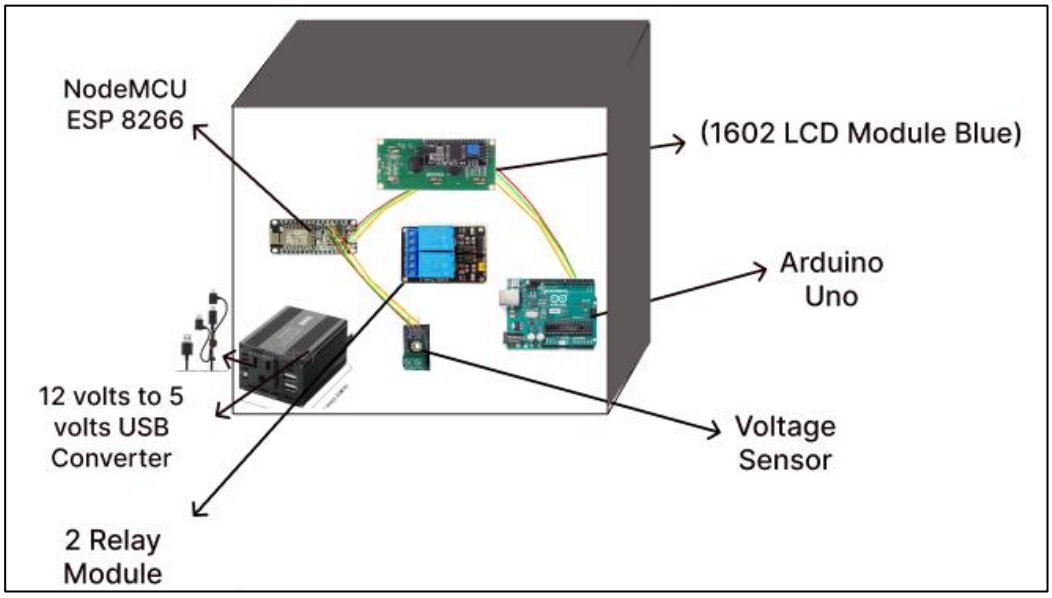


Figure 3.12 Top Box Prototype

1. **Node MCU ESP8266 –** This component is responsible for an integrated support for WIFI networks, and has lower energy consumption.
2. **12 Volts to 5 Volts USB Converter –** This component converts a 12V power supply into a stable 5V output.
3. **2 Relay Module –** This module acts as a switch, allowing low power microcontrollers like Arduino to control high-power electrical devices.
4. **Arduino Uno –** This microcontroller is responsible for processing input signals, controlling relays, and interfacing with sensors.
5. **Voltage Sensor –** This sensor measures voltage levels in an electrical circuit.

Battery Storage Box

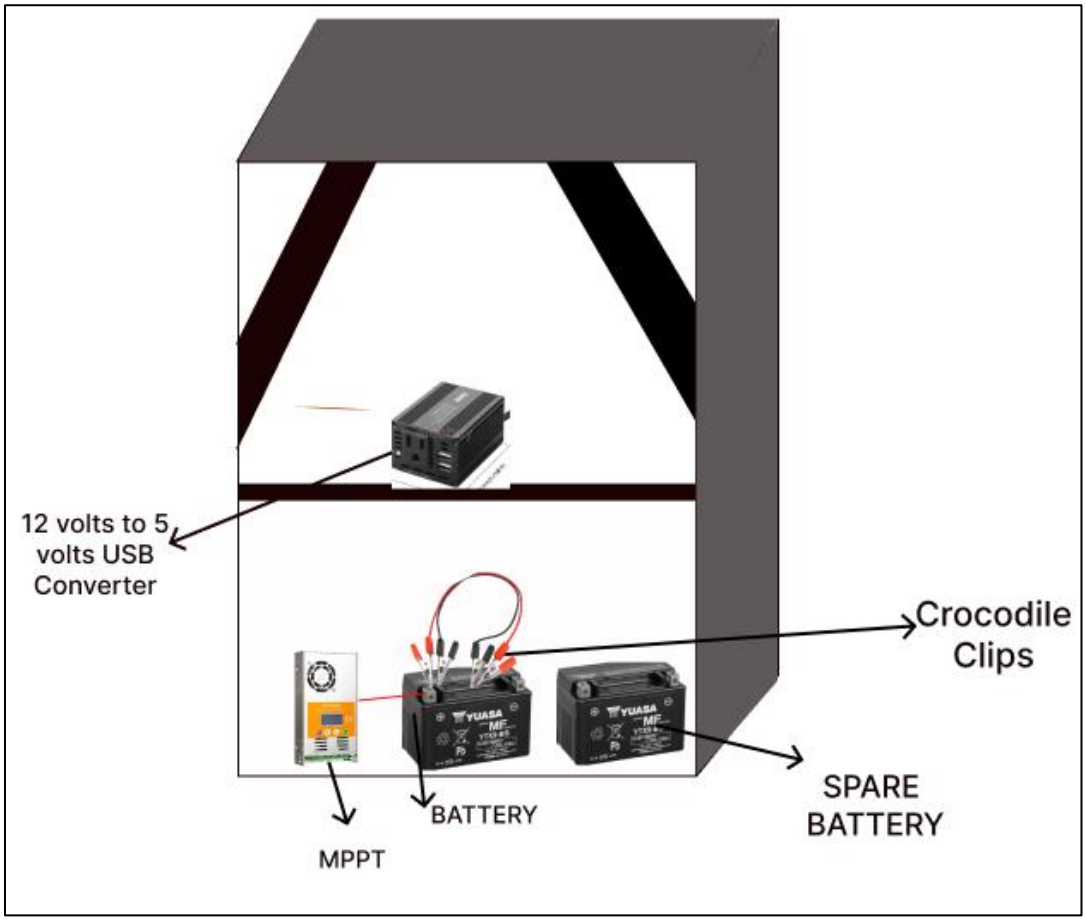


Figure 3.13 Lower Box Prototype

Schematic Diagram A

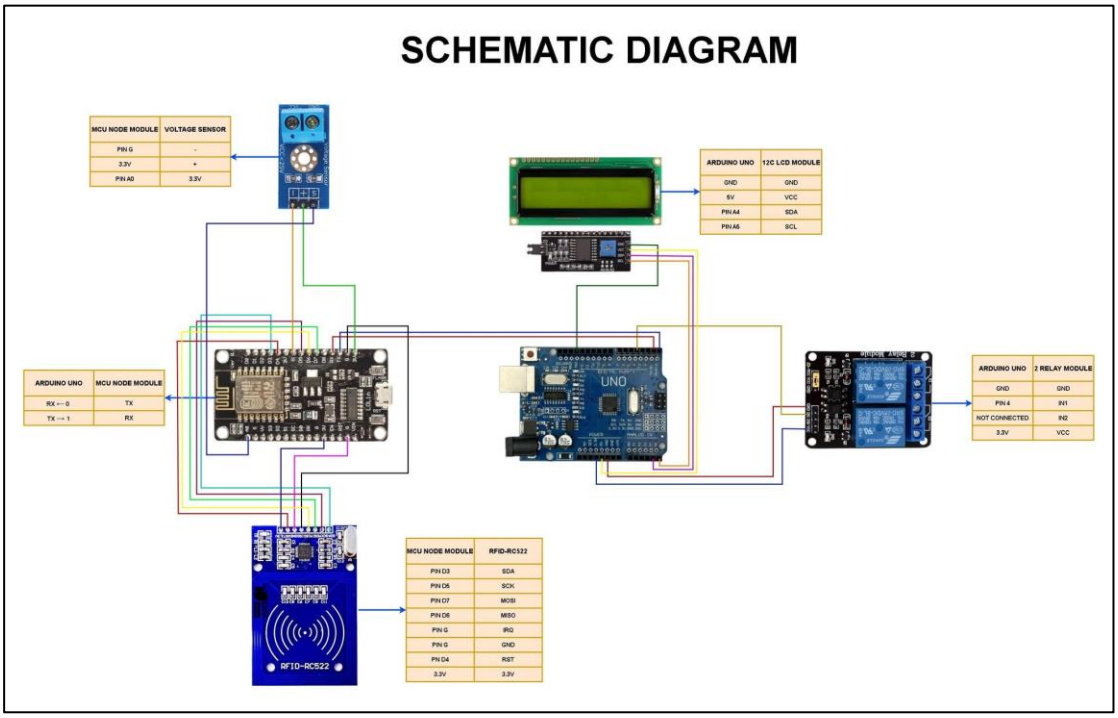
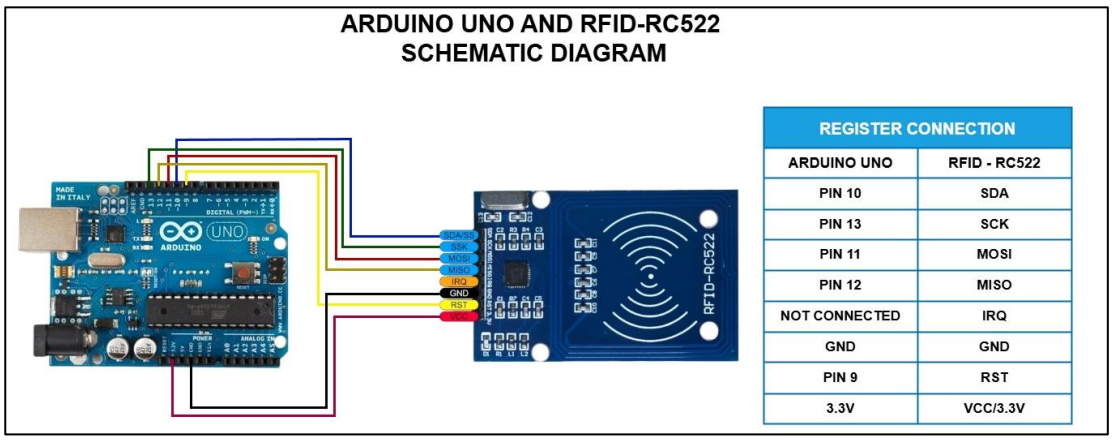


Figure 3.14 Schematic Diagram of Top Box

Schematic Diagram B



REGISTER CONNECTION	
ARDUINO UNO	RFID - RC522
PIN 10	SDA
PIN 13	SCK
PIN 11	MOSI
PIN 12	MISO
NOT CONNECTED	IRQ
GND	GND
PIN 9	RST
3.3V	VCC/3.3V

Figure 3.15 Schematic Diagram of Arduino Uno and RFID-RC522

Full Connection of Hardware Wirings Blueprint

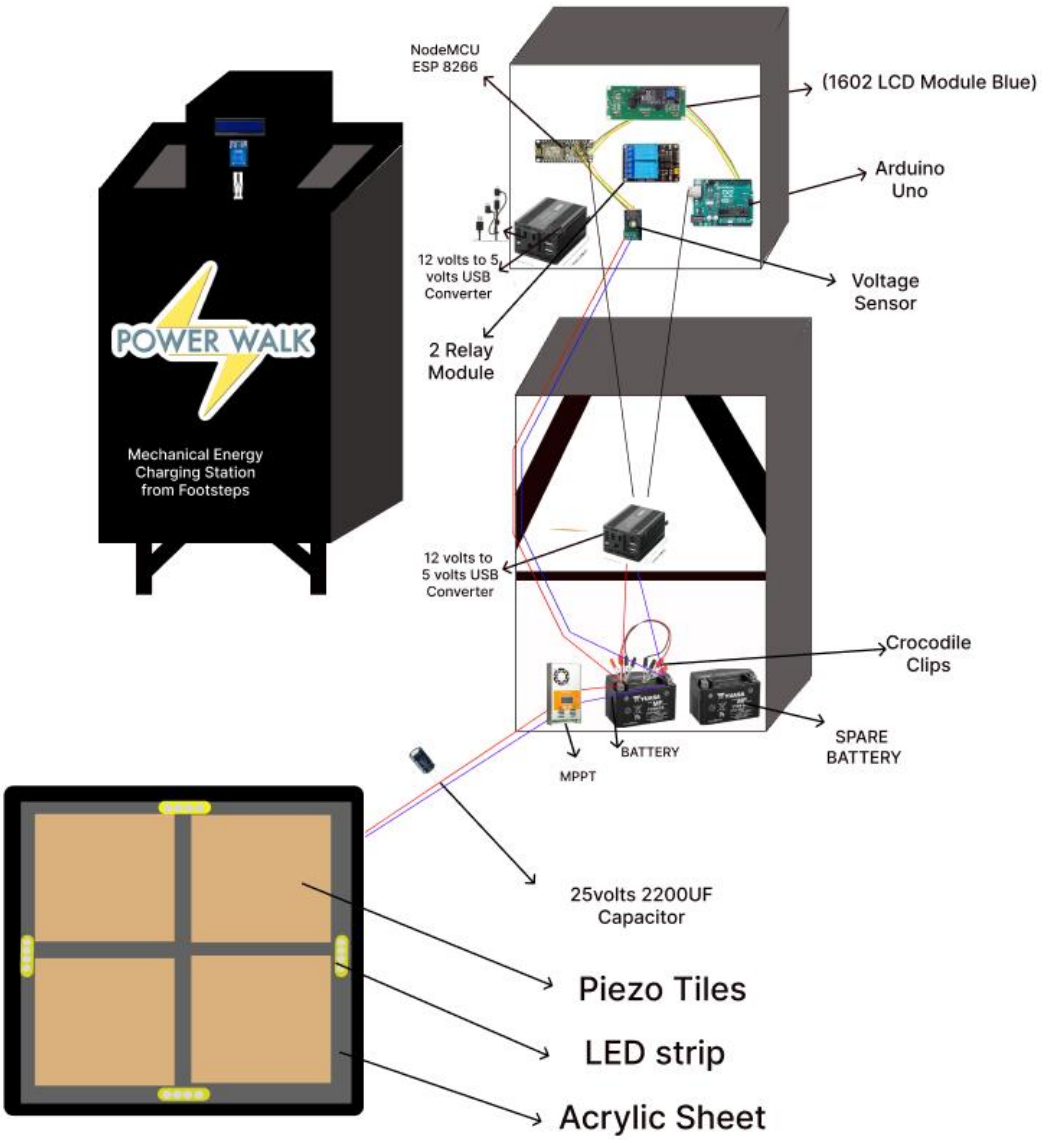


Figure 3.16 Full Connection of Hardware Wirings Blueprint

Blueprint of Piezo Tiles

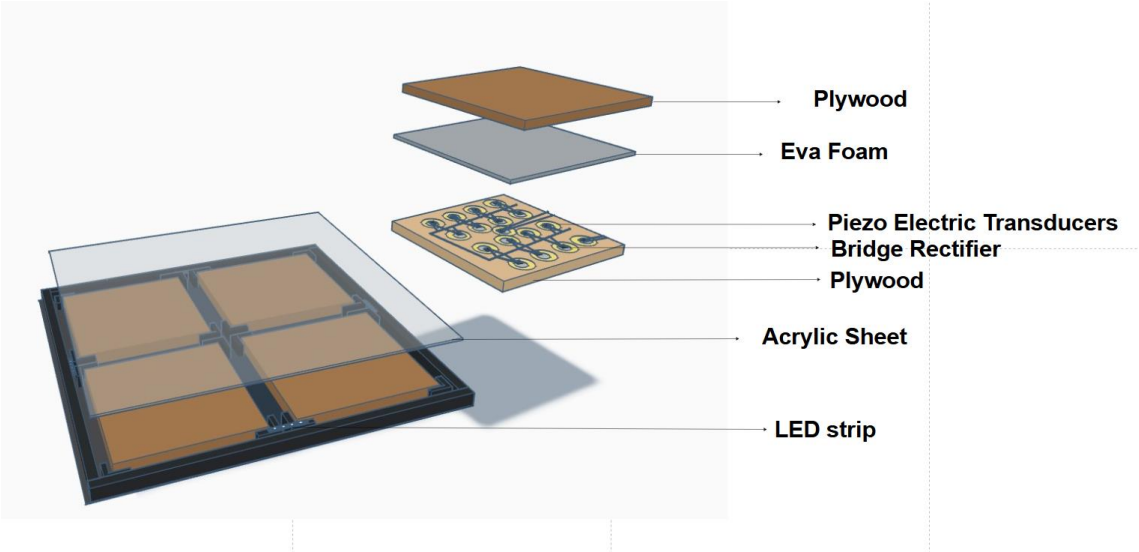


Figure 3.17 Piezo Tiles Blueprint

Plywood – This wood is to provide structural support, it acts as a sturdy base that offers stability and security for mounting parts including cables, circuit boards, and sensors.

Eva Foam – A flexible, lightweight, and shock-absorbing material for insulation and cushioning. It assists in shielding delicate electronic parts from impacts, vibration, and outside environmental influences.

Piezo Transducers – These components convert kinetic energy into electrical energy.

Bridge Rectifier – It ensures a stable DC voltage output, making it essential for powering electronic circuits that require steady power.

Acrylic Sheet – This part provides insulation, protection against dust or moisture, and a professional finish for devices.

Led Strip - is a flexible circuit board that is populated with LEDs that you can stick almost anywhere you want to add powerful lighting in a variety of colors and brightnesses

3.9 Project Development Cost (Cost – Benefit Analysis)

Table 3.4 Project Development Cost of Powerwalk Charging Station for QCU in 2 months

Personnel Salary

Personnel	Number	Salary	Monthly Amount	Total Amount
Project Manager	1	₱34,771.00	₱34,771.00	₱69,542.00
Head Programmer	1	₱61,293.00	₱61,293.00	₱112,586.00
Head Technical Writer	1	₱66,248.00	₱66,248.00	₱132,496.00
Head System Analyst	1	₱59,514.00	₱59,514.00	₱119,028.00
Back-end Developer	2	₱53,883.00	₱107,766.00	₱215,532.00
Front End Developer	2	₱52,686.00	₱105,372.00	₱210,744.00

Personnel	Number	Salary	Monthly Amount	Total Amount
UI/UX Designer	1	₱46,942.00	₱46,942.00	₱93,884.00
System Analyst	1	₱33,642.00	₱33,642.00	₱67,284.00
Quality Assurance	2	₱25,282.00	₱50,564.00	₱101,128.00
Technical Writers	6	₱32,971.00	₱65,942.00	₱131,884.00
Electrical Engineer	2	₱23,666.00	₱47,332.00	₱94,664.00
TOTAL COST				₱1, 348,772.00

Hardware Material Costing

Quantity	Item	Unit Cost	Total
1	Plywood	₱720	₱1440.00
1/2	Plywood	₱600	₱1200.00
3	2x2 Wood	₱550	₱550.00
2	2x1 Wood	₱400	₱400.00
1	Latex Black Paint	₱250	₱250.00
1	Latex Black Paint	₱250	₱250.00
2	Cabinet Lock	₱105	₱210.00
1	Cream Hardener	₱95	₱95.00
1	Polyster Body Filler	₱240	₱240.00
1/2kg	Common Nail 2d 1/4kg	₱0	₱20.00
1/2kg	Common Nail 30d 1/4kg	₱20	₱40.00
2	Stainless Door Hinges	₱168	₱336.00
1 meter	Eva Foam (Black) (3mm)	₱240	₱240.00
1	73.5x 73.5 cm Acrylic Sheet	₱850	₱850.00
Total Cost			**₱6,121.00**

Hardware Components Costing

Quantity	Item	Unit Cost	Total
1	Arduino Uno	₱299	₱299.00
1	NodeMCU	₱160	₱160.00
1	LCD1602 +12C Blue Screen	₱110	₱110.00
1	RC522 MFRC-52213.56Mhz RFID card reader Module	₱79	₱79.00
1	Voltage Detection Sensor	₱44	₱44.00
1	Relay Module 12v	₱59	₱59.00
	Jumper Wire Male to Female	₱120	₱210.00
1	Jumper Wire Male to Male	₱150	₱150.00
10 meters	Speaker Double Cable Wire	₱300	₱300.00
2	12v Motorcycle Battery	₱650	₱1,300.00
120	Piezoelectric Transducer	₱1800	₱3,600.00
10	MB6S Bridge Rectifier	₱54	₱54.00
2	3A 3 in 1 Fast Charging Data Cable	₱170	₱170.00
4	3LED Light Module with Lens 12v DC	₱50	₱50.00
1	MPPT Solar Charge Controller	₱2,675	₱2,675.00
Total Cost			**₱9,260.00**

Software Costing

Software	Cost	Total Price
Visual Studio Code	Free	₱0.00
Arduino Uno App	Free	₱0.00
Tinkercad	Free	₱0.00
Figma	Free	₱0.00
Total Cost		₱0.00

Expenses

Particular	Total Price
Personnel	
Hardware Material Cost	**₱6,121.00**
Hardware Components Cost	**₱9,260.00**
Software	**₱0.00**
Grand Total	**₱ 15,381.00**

Summary of Operational Cost

Particular	Cost Amount
Personnel	**₱1, 348,662.00**
Expenses	**₱15,381.00**
Total	**₱1,364, 153.00**

3.10 Development and Testing

The development and testing phase of the **"POWERWALK":** Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation was the most vital in ensuring the system's overall performance and quality. This phase involved the implementation of the system's functionalities, based on the researched

requirements during the analysis phase, followed by constant testing to ensure its full performance.

Development

The project followed the Agile Methodology, with the system divided into sections called sprints. The different sprints were all focused on specific features or enhancements, with the help of the students as the user feedback and the staffs for the admin feedback. The development team, especially the hardware and software team researched rigorously to translate the requirements into a working software.

During each sprint, tasks were made, and progress was updated through the development team through videos and chats and face to face meetings.

Continuous tests were made to ensure that there are no errors occurring. The iterative development approach, allowed for constant improvements and adjustment based on students and staffs feedback.

Testing

Black-box Testing

Black box testing, a form of functional testing, was employed to evaluate the system's behavior without examining its internal code structure. This testing method focused on validating the system's inputs and outputs against specified requirements, ensuring that it functioned correctly from an end user perspective.

Table 3.5 Black Box Testing

Software Test Plan

Table 3.5 Software Testing Plan

TSID	*TCID*	*Test Case*	*Test Case Description*	*Scenario*	*Pre - Condition*	*Steps to Execute*	*Expected Results*	*Remarks*
TS01_Login	TS01_Login_TC01_1	Successful Admin Login	Checks if an admin with the correct email and password can log in.	An admin tries to log in with valid credentials.	There must be an admin account already created.	Enter the correct email and password. Click the "Sign In" button.	The system takes the admin to the dashboard.	Passed
	TS01_Login_TC02_1	Unsuccessful Login (Incorrect Credentials)	Ensures unauthorized users cannot log in.	A user enters the wrong email or password.		Enter an incorrect email or password. Click "Sign In."	The system shows an error message.	Passed
	TS01_Login_TC03_1	Login with Empty Fields	Ensures the system does not allow logging in with empty fields.	A user tries to log in without entering an email or password.		Leave the email and password fields blank. Click "Sign In."	The system shows a validation error message.	Passed
TS01_Dashboard	TS01_Dashboard_TC01_1	Display of Electricity Generated & Consumed	Ensures the dashboard shows real-time electricity data.	An admin checks the system's energy data.	Power should be actively generated.	Log in to the system. Check the "Electricity Generated" and "Consumption" sections.	The numbers update correctly as energy is generated and used.	Passed
	TS01_Dashboard_TC02_1	Dashboard Graph Updates Correctly	Ensures the daily usage graph reflects activity	The system updates the graph when	At least 1 RFID scan recorded	Scan RFID to charge.	The dashboard graph updates	Passed

				RFID scans occur.			accordingly .	
	TS01_Dashboard_TC03_1	Battery Percentage Indicator	Ensures the battery percentage updates when power is generated.	The battery level should increase as energy is stored	Power is generated	Generate power. Check the battery percentage indicator.	The battery level increases.	Passed
	TS01_Dashboard_TC03_2		Ensures the battery percentage updates when power is consumed.	The battery level should decrease as energy is used.	Power is consumed.	Plug a device into the charging station to consume power. Observe the battery percentage indicator on the dashboard.	The battery level decreases as power is consumed.	Passed
TS01_RFID	TS01_RFID_TC01_1	Successful RFID Registration	Ensures new RFID tags can be added.			Click the "+ Register RFID" button. Tap the RFID card.	The RFID is successfully added to the system.	Passed
	TS01_RFID_TC02_1	Prevent Duplicate RFID Registration	Ensures the system does not allow duplicate RFIDs.		The RFID being added must already exist in the system.	Tap the RFID.	Error message appears	Passed
	TS01_RFID_TC03_1	RFID Search Functionality	Ensures the system can search for existing RFIDs.		At least one RFID should be registered.	Enter RFID in search bar	The system filters and displays the correct RFID.	Passed
	TS01_RFID_TC04_1	RFID Search for Non-Existent RFID	Ensures the system properly handles searches for unregistered RFIDs.			Enter an RFID number that is not in the system. Press the search button.	Shows "No results found"	Passed
TS01_Logout	TS01_Logout_TC01_1	Successful Log Out	Ensures users can log out safely	A user should be able to log out of the system.	The user must be logged in.	Click the "Logout" button.	The system redirects the user to the login page.	Passed
	TS01_Logout_TC02_1	Prevent Access to Dashboard After Logout	Ensures that logged-out users cannot access the dashboard.	After logging out, users should not be able to return to the dashboard.	The user must have logged out.	Try to access the dashboard using the browser's back button or by revisiting the dashboard URL.	The system redirects the user back to the login page, preventing unauthorized access.	Passed

Hardware Test Plan

Table 3.6 Hardware Testing Plan

TSID	*TCID*	*Test Case*	*Test Case Description*	*Scenario*	*Pre - Condition*	*Steps to Execute*	*Expected Results*	*Remarks*
TS01_Power Generation	TS01_PowerGeneration_TC01_1	Piezoelectric Tile Energy Generation	Ensure the piezo tiles generate electricity when stepped on.	A Student stepped on the piezo tiles.	The piezoelectric tiles must be properly installed and connected.	☐ Step on the piezoelectric tiles multiple times. ☐ Check if the battery receives and stores the generated energy.	The system successfully converts kinetic energy into electrical energy and battery percentage increases as energy is stored.	Passed
TS01_Power Storage	TS01_PowerStorage_TC01_1	Battery Storage	Ensure the generated power is properly stored in the battery.	The battery should charge as energy is generated.	The battery is connected.	☐ Step on the piezo tiles multiple times. ☐ Use a tester to check battery voltage. ☐ Observe if the voltage level increases.	The battery percentage increases as more energy is stored.	Passed
	TS01_PowerStorage_TC01_2		Ensure the system stops charging when the battery reaches 100%.	Charging should stop automatically to prevent overcharging.		☐ Continuously generate energy until the battery reaches 100%. ☐ Monitor the battery status on the dashboard.	The system stops charging once the battery reaches full capacity.	Passed
TS01_Power Usage	TS01_PowerUsage_TC01_1	Power Consumption	Ensure that stored energy is properly utilized when a device is plugged into the charging station.		The system must have stored energy	☐ Confirm that there is stored energy in the system. ☐ Plug a mobile device into the charging port. ☐ Observe the battery percentage indicator.	The battery level decreases as power is consumed.	Passed
TS01_RFID Scanner	TS01_RFIDScanner_TC01_1	RFID Authentication	Ensure that only registered users can access the charging station.		At least one RFID card must be registered in the system.	☐ Tap a registered RFID card on the scanner. ☐ Observe the system response.	The system grants access and allows charging.	Passed
	TS01_RFIDScanner_TC01_2		Ensure that unregistered RFID cards cannot access the charging station.			☐ Tap an unregistered RFID card on the scanner. ☐ Observe the system response.	The system denies access and displays an error message.	Passed
	TS01_RFIDScanner_TC02_1	RFID Verification	Ensure the system correctly handles multiple RFID scans while an active session is ongoing.		At least two RFID cards must be registered.	☐ Tap the first RFID card and start a charging session. ☐ Before the session expires, tap a second RFID card.	The second RFID scan is ignored while the first session is active.	Passed

	TS01_RFIDScanner_TC02_2		Ensure that tapping an RFID card mid-session does not reset an ongoing charging session.	A user is charging their device when another RFID card is tapped.		❑ Tap a registered RFID card to start a charging session. ❑ While charging is in progress, tap the same RFID card again.	The system ignores repeated taps from the same card.	Passed
	TS01_RFIDScanner_TC02_3		Ensure that tapping an RFID card mid-session does not interrupt an ongoing charging session.	A user is charging their device when another RFID card is tapped.		❑ Tap a registered RFID card to start a charging session. ❑ Tap a different registered RFID card mid-session.	Tapping a different registered RFID card during an active session is also ignored, and the session continues uninterrupted.	Passed
	TS01_RFIDScanner_TC02_4		Ensure that the system properly handles unreadable or damaged RFID cards.	A damaged RFID card is tapped on the scanner.		❑ Tap a valid registered RFID card to confirm normal operation. ❑ Tap a damaged, scratched, or defective RFID card.	The system does not grant access.	Passed

						❑ While charging is in progress, tap the same RFID card again.	the same card.	
	TS01_RFIDScanner_TC02_3		Ensure that tapping an RFID card mid-session does not interrupt an ongoing charging session.	A user is charging their device when another RFID card is tapped.		❑ Tap a registered RFID card to start a charging session. ❑ Tap a different registered RFID card mid-session.	Tapping a different registered RFID card during an active session is also ignored, and the session continues uninterrupted.	Passed
	TS01_RFIDScanner_TC02_4		Ensure that the system properly handles unreadable or damaged RFID cards.	A damaged RFID card is tapped on the scanner.		❑ Tap a valid registered RFID card to confirm normal operation. ❑ Tap a damaged, scratched, or defective RFID card.	The system does not grant access.	Passed
TS01_Piezo Tiles	TS01_PiezoTiles_TC01_1	PiezoElectric Tiles Durability	Ensure the piezo tiles withstand repeated heavy usage without damage.			Multiple students stepping simultaneously.	No cracks or hardware malfunctions occur.	Passed

	TS01_PiezoTiles_TC01_2		Ensure the tiles continue functioning if one piezoelectric transducer stops working.		One transducer is intentionally disconnected or damaged.	Disable or damage one of the transducers.	The system should still generate energy with the remaining transducers.	Passed
	TS01_PiezoTiles_TC01_3		Verify how the tiles react when one of the piezoelectric transducers is unable to generate energy due to malfunction or disconnection.			Check LED indicators for fault detection.	The LED indicator light will determine if a piezoelectric transducer is faulty when it does not light up.	Passed
	TS01_PiezoTiles_TC01_4		Verify how the tiles react when the piezoelectric transducers come into contact with moisture.		An LED indicator must be connected to detect energy generation.	Moisten your fingers and lightly press the piezoelectric transducer. Observe the LED indicator – it should not light up.	When wet, the piezoelectric transducer does not generate power, and the LED does not light up.	Passed

3.11 Data Analysis Plan

For Data Analysis, the study employed a weighted mean method to calculate the proposed system based on criteria adapted from ISO 25010. To evaluate the quality of the products. 377 respondents participated in the testing process. Data collection utilized both observation and questionnaires, with the instrument being a Likert scale-based questionnaire. The data analysis technique involved descriptive analysis, focusing on quantitative data.

Table 3.7 Likert Scale Interpretation

Scale	Range	Verbal Interpretation
5	4.51 – 5.00	Strongly Agree
4	3.51 – 4.50	Agree
3	2.51 – 3.50	Neutral
2	1.51 – 2.50	Disagree
1	1.00 – 1.50	Strongly Disagree

The obtained responses from the questionnaire were subject to analysis using the weighted mean approach. This method involved calculating the mean

score by considering the weight of each response category. The formula used to get the mean score was:

Formula:

$$\left| \bar{x} = \frac{\sum fx}{n} \right|$$

Where:

$\boldsymbol{x = mean}$

$\boldsymbol{\sum fx = summation\ of\ response}$

$\boldsymbol{n = total\ number\ of\ respondents}$

The calculated weighted mean provided an average score reflecting the evaluation of the application based on the ISO 25010 criteria. Interpretation of the results was carried out using predefined indicators, which categorized scores into different satisfaction levels ranging from "Highly Satisfied to "Not Satisfied at all" The formula used to get the weight mean was:

Formula: $$WMP = \frac{\sum f\ (x1+x2+\cdots xn)}{n}$$

Where:

WMP = Weighted Mean of the Proposed System

$\sum f\ (x1 + x2 + \cdots xn)$ = sum of all means of each criterion

n = total number of criteria

3.12 Implementation Plan

The implementation plan for the capstone project provides an overview of the deployment process, focusing on integrating piezoelectric tiles with an Arduino Uno system and RFID technology to create a sustainable charging station. This plan outlines the steps needed to ensure proper installation, testing, and deployment of the system within Quezon City University.

Once the system is finalized, it will be presented to the university administration and potential users. If approved, the project team will oversee the deployment and provide necessary documentation for maintenance and future improvements. A memorandum of agreement may be issued, stating the transfer of system ownership while clarifying that future updates and maintenance will be

the institution's responsibility. To ensure a smooth implementation, the team will employ structured strategies, detailed in the table below.

1. The researchers should finish the system and hardware upon the due date by their mentors, beneficiary and stakeholders. The production of each process in the software and hardware is dependent to the researchers as long as they meet the required deadline of the university.
2. The researchers and beneficiary must agree upon an agreement of terms and conditions in regards to implementing the system. The signing of the agreement also includes sections about liabilities and rights regarding both parties involved when it comes to ownership and control of the Powerwalk Charging Station.
3. The Launching of required software for the system to run will be done by the head programmer of the Powerwalk charging station together with the hardware and other development members to ensure the functionalities of the system will be working properly, and to take in consideration how the implementation can be scaled up starting from the number of devices that can charge at the Powerwalk charging station simultaneously, up to how the software can adapt over time.

4. A thorough evaluation of the software and hardware of the Powerwalk station functionalities, can be made by conducting a user testing with the main target users of the system. These evaluations that are being conducted will estimate the system's ability to perform its main tasks and ensure it meets the overall functional requirements.

5. The researchers will solidify its documentation to ensure the personnel that will be monitoring the system, will be knowledgeable and aware of new processes and functions found in the system.

6. To ensure that there are no potential issues from the system, the researchers will schedule annual visitation for the checking of any abnormalities especially for the Powerwalk charging station, mainly the Piezo tiles for their condition.

Table 3.8: Implementation Plan

STRATEGY	ACTIVITIES	PERSON INVOLVED	DURATION
Approval from the Research Management office	1. Conduct an interview 2. Obtain letter of approval from RMO	1. Director of RMO 2. Researchers	1 day
System Design and Architecture	Design the overall system architecture, including piezoelectric tile placement, power conversion circuits, energy storage, and charging station setup. Define the data flow for RFID authentication	System Analyst, Researcher, Programmers	4 weeks

	and power monitoring..		
Software Development and Implementation	Develop Arduino code for RFID authentication, power monitoring, and data logging. Implement a user interface for monitoring energy usage. Integrate software with hardware.	Researcher, Programmers	5 weeks
Hardware Development and Testing	Assemble and test piezoelectric tiles, rectifiers, capacitors, and battery storage. Ensure proper integration with	Researcher, Programmers	6 weeks

	the charging station. Conduct power output tests..		
System Testing	Conduct full-scale tests: Verify power efficiency, test RFID access, monitor charge output, and conduct stress tests on piezoelectric tiles..	System Analyst, Programmers, Researcher	3 weeks
Deployment and User Training	Install the charging station at Quezon City University. Conduct user training for admin on RFID authentication and charging procedures.	Project Manager, System Analyst, Researcher	2 weeks

System Evaluation and Documentation	Evaluate energy efficiency, user feedback, and overall system performance. Document system design, user manuals, and recommendations for future improvements.	Project Manager, System Analyst, Documentation, Researcher	2 weeks

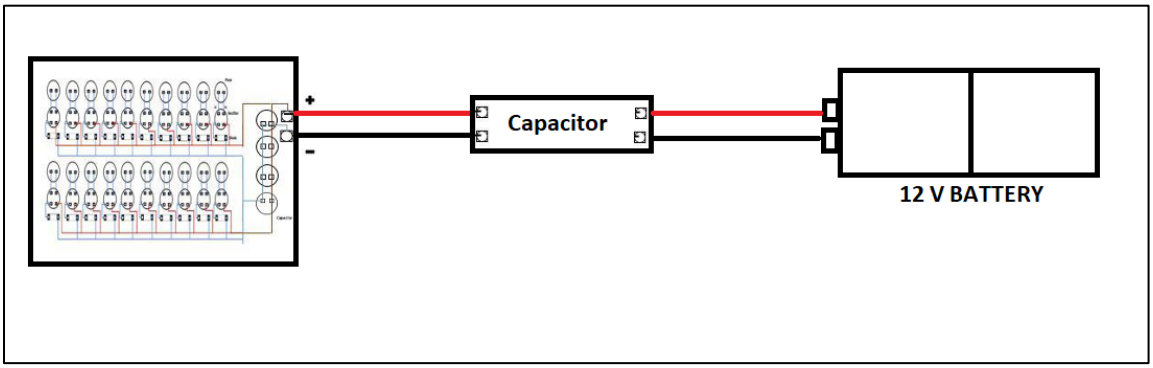
Key Dates

Project Start Date: October 05, 2024

Project End Date: March 18, 2025

Total Duration: 24 weeks

Figure 3.18 Flow Circuit Diagram



Chapter 4
Results and Discussions

This section presents the statistical data results in relation to the specific objectives found in Chapter 1. This section of the study includes the corresponding data analysis and interpretation of data gathered from the respondents.

4.1 Results

1. The results of the interview conducted with students, staff, and guards of QCU San Bartolome revealed several key findings. The primary reason students are not allowed to charge their devices within campus buildings is due to safety concerns raised by the school administration. These include the risk of short circuits, potential elevator malfunctions, damage to digital records, and even the threat of fires. Despite this policy, many students admit to charging their devices in secret when faculty and staff are not present, highlighting the necessity of staying connected. This behavior often stems from the challenges they face during emergencies or when they need to submit assignments or conduct research using their phones. As a result, the researchers suggest that the implementation of a designated charging station for student use could effectively address these needs while upholding safety protocols.

Figure 4.1 Screenshot of Software with Explanation of SO #2

2. This screenshot shows the tracking of energy generation and consumption in the battery displayed and report real-time energy usage of the students using the Powerwalk Charging station, being displayed in the Dashboard of the software.

Figure 4.2 LCD of Hardware with Explanation of SO #3

3. The researchers were able to develop a charging by using an alternative source for electricity from human footsteps, because of this the Powerwalk

charging station isn't connected to the power grid of the school, resulting to an eco- friendly source of power. And to add, the charging is focused on catering the students, that's why the students are the only one who are allowed to use the charging station.

Figure 4.4 Piezo Tile with Explanation of SO #4

Figure 4.3 Powerwalk Charging Station with Explanation of SO #4

4. The figure 4.3 and figure 4.4 shows that the researchers were able to use piezoelectricity using piezo transducers as the tool in converting kinetic energy from the students walking into the tiles. We were also able to calculate the footsteps needed to charge the battery.

Computation for the steps needed to charge the battery to 1%

1.) Voltage × Current = Power (W)

$P = V \times I$

2.) Energy Needed for 1% Charge (Wh)

E needed = Battery Energy × 0.01

3.) Time Required (h)

t = E needed/P

4.) Convert Time to Steps (Assuming 1 step per second)

Steps = t × 3600

Example Calculations:

1 Tile (12V, 0.125A → 1.5W)

1.) P = 12V × 0.125A = 1.5W

2.) E needed = 48Wh × 0.01 = 0.48

3.) t = 0.48Wh/1.5W = 0.32h

4.) Steps = 0.32 × 3600 = 1152

Steps Required: **1152**

2 Tiles (12V, 0.25A → 3W)

1.) P = 12V × 0.25A = 3W

2.) E needed = 48Wh × 0.01 = 0.48

3.) t = 0.48Wh/3W = 0.16h

4.) Steps = 0.16 × 3600 = 576

Steps Required: 576

3 Tiles (12V, 0.375A → 4.5W)

1.) P = 12V × 0.375A =4.5W

2.) E needed = 48Wh × 0.01 = 0.48Wh

3.) t = 0.48Wh/4.5W = 0.107h

4.) Steps = 0.107× 3600 = 384

Steps Required: 384

4 Tiles (12V, 0.5A → 6W)

1.) P = 12V × 0.125A = 6W

2.) E needed = 48Wh × 0.01 = 0.48

3.) t = 0.48Wh/6W = 0.08h

4.) Steps = 0.08 × 3600 = 288

Steps Required: 288

Steps Required per Tile Setup

1 Tile: 1152 steps

2 Tiles: 576 steps

3 Tiles: 384 steps

4 Tiles: 288 steps

Computation for the steps needed to charge the battery to Full charge

Given:

Battery = 12v x 4AH= 48 watts
Piezo tiles (60 PiezoElectric Transducer) = 12v x 0.5 Ampere = 6 Watts

Formula: 48 watts / 6 watts = 8

Let's say in 1 Hour there are 3600 steps:

60 mins x 60 secs = 3600 steps/secs

To full charge the 12v 4Ah Battery:

Formula: 8 x 3600 steps/secs = 28,800 steps

Figure 4.5 Before and After of Phone Battery after 15 charging time with Explanation to SO# 4

In figure 4.5, the researchers were able to prove that piezo electricity can power their mobile phones in the given 15 minutes. In every 15 minutes, the researchers have proved the estimated battery life added to the phone is 12%.

This is the formula used by the researchers to compute how many percent is added to the phone for 15 minutes with the volts and amp of a phone and battery used in the research.

Computation for the Battery Percentage Added within 15 minutes of Charging Time

1.) V x I= Power (w)

2.) Power x Time x Efficiency = Watt-Hour (Energy Wh)

3.) Wh x 1000mWh / V = mAh delivered

4.) mAh delivered / battery capacity x 100 = Percentage

Example of 5000mAh battery

a.) V x I = Power (w)

5v x 3A = 15w

b.) Power x Time x Efficiency = Watt-Hour (Energy Wh)

15 x 0.25 x 0.85 = 3.19Wh

c.) Wh x 1000mWh / V = mAh delivered

3.19wh x 1000mWh / 5 = 638mAh

d.) mAh delivered / battery capacity x 100 = Percentage

638mAh/ 5000mAh x100 = 12.76 % Battery Added

For 4000mAh = 15.95% Battery Added
For 6000mAh = 10.63% Battery Added

And here are some factors on charging to take in consideration when charging into the Powerwalk Station.

Factors Affecting Battery Percentage Charging Time

- Battery Health: Over time, the capacity of a battery can be degraded. If the battery is not in perfect condition, it might not charge as efficiently as when it was new.
- Device Usage During Charging: If the phone is being used while charging, some of the supplied power is consumed by the phone's operations, reducing the amount available for charging the battery.
- Temperature: Charging at high or low temperatures can affect the charging efficiency. Batteries charge less efficiently when they are too hot or too cold.

Figure 4.6 Screenshots of the Scanning of Unregistered RFID Card with Explanation to SOP #5

Figure 4.7 Screenshots of the Scanning of Registered RFID Card with Explanation to SOP #5

5. The figures 4.6 and 4.7 shows how the system didn't allow unregistered IDs to charge in the Powerwalk Station, meanwhile when it's scanned as registered, that is where the 15 minutes will show and allow you to charge.

Figure 4.8 Screenshots of the Charging Ports with Explanation to SOP #6

6. The figure 4.8 shows that the Powerwalk Station provides 3 charging ports which are, USB Lightning, USB-C and MICRO USB.

7. With the efforts of the researchers and the University's goal in encouraging in innovation when it comes to sustainable efforts, the researchers are conducting a patent search and copyright process to attain it's full rights to be used to the school in the future.

4.2 Statistical Results of Survey Questionnaire

STUDENT EVALUATION SURVEY RESULTS

Table 4.1 Mean, Verbal Interpretation, and Description of the Performance Efficiency Based on the Students Evaluation Questionnaire.

PERFORMANCE EFFICIENCY	MEAN	VERBAL INTERPRETATION
Does the Powerwalk Station quickly charge your device?	4.15	Agree
Is the Powerwalk Station efficient in how it works?	4.43	Strongly Agree
Does the Powerwalk Station perform well for students?	4.53	Strongly Agree
Total Overall Mean	**4.37**	**Agree**

Table 4.1 shows the evaluation results for Performance Efficiency based on the Evaluation of 372 students of Quezon City University San Bartolome Campus. The attributes: "Does the Powerwalk Station quickly charge your device?", "Does the Powerwalk Station efficient in how it works?", "Does the Powerwalk Station perform well for students?" In total the Performance Suitability of the system based on the evaluation questionnaire given to the students of QCU at San Bartolome Campus is 4.37 with the verbal interpretation "Agree".

Table 4.2 Mean, Verbal Interpretation, and Description of the Security Based on the Students Evaluation Questionnaire.

SECURITY	MEAN	VERBAL INTERPRETATION
Does the Powerwalk Station allow only registered student IDs to charge?	4.36	Strongly Agree
Does the Powerwalk Station block unregistered IDs from charging?	4.33	Strongly Agree
Do you feel that your device is safe while using the Powerwalk Station?	3.97	Agree
Total Overall Mean	**4.22**	**Agree**

Table 4.2 shows the evaluation questionnaire results for the Security of the evaluation of 372 students of Quezon City University San Bartolome Campus. The attributes are "Does the Powerwalk Station allow only registered student IDs to charge", "Does the Powerwalk Station block unregistered IDs from charging?", "Do you feel that your device is safe while using the Powerwalk Station?" In total the Security of the System based on the evaluation of the questionnaire given to the students of QCU at San Bartolome Campus is 4.22 with the verbal interpretation "Agree".

Table 4.3 Mean, Verbal Interpretation, and Description of the Usability Based on the Students Evaluation Questionnaire.

USABILITY	MEAN	VERBAL INTERPRETATION
Is the Powerwalk Station easy to use for charging?	4.41	Strongly Agree
Is it easy to check how much charging time is left for students?	4.42	Strongly Agree
Can you understand how to use the Powerwalk Station without needing help?	4.26	Strongly Agree
Total Overall Mean	**4.36**	**Agree**

Table 4.3 shows the evaluation questionnaire results for the Usability of the evaluation of 372 students of Quezon City University San Bartolome Campus. The attributes are "Is the Powerwalk Station easy to use for charging?", "Is it easy to check how much charging time is left for students?", "Can you understand how to use the Powerwalk Station without needing help?" In total the Usability of the system based on the evaluation questionnaire given to the students of QCU at San Bartolome Campus is 4.36 with the verbal interpretation "Agree".

Table 4.4 Mean, Verbal Interpretation, and Description of the Compatibility Based on the Students Evaluation Questionnaire.

COMPATIBILITY	MEAN	VERBAL INTERPRETATION
Does the Powerwalk Station work with your mobile device?	4.46	Strongly Agree
Does the Powerwalk Station provide the right port for your device?	4.40	Agree
Can you charge different types of devices using the Powerwalk Station?	4.44	Strongly Agree
Total Overall Mean	**4.43**	**Agree**

Table 4.4 shows the evaluation questionnaire results for the Compatibility Of the evaluation of 372 students of Quezon City University of San Bartolome Campus. The attributes are "Does the Powerwalk Station work with your mobile device?", "Does the Powerwalk Station provide the right port for your device?", "Can you charge different types of devices using the Powerwalk Station?" In total the compatibility of the system based on the evaluation questionnaire given to the students of QCU at San Bartolome Campus is 4.43 with the verbal interpretation "Agree".

Table 4.5 Mean, Verbal Interpretation, and Description of the Reliability Based on the Students Evaluation Questionnaire.

RELIABILITY	MEAN	VERBAL INTERPRETATION
Is the Powerwalk Station helpful in emergencies? (e.g., charging for submitting an assignment or making an urgent call/text)	4.58	Strongly Agree
Does the Powerwalk Station encourage students to use it?	4.46	Strongly Agree
Is 15 minutes enough for an emergency charge?	4.17	Agree
Total Overall Mean	**4.40**	**Agree**

Table 4.5 shows the evaluation questionnaire results for the Usability of the evaluation of 372 students of Quezon City University San Bartolome Campus. The attributes are "Is the Powerwalk Station helpful in emergencies? (e.g., charging for submitting an assignment or making an urgent call/text)", "Does the Powerwalk Station encourage students to use it?", "Is 15 minutes enough for an emergency charge?". In total the Reliability of the system from the evaluation questionnaire given to the students of QCU San Bartolome Campus is 4.40 with the verbal interpretation "Agree".

ADMIN EVALUATION SURVEY RESULTS

Table 4.6 Mean, Verbal Interpretation, and Description of the Maintainability Based on the Admin Evaluation Questionnaire.

MAINTAINABILITY	MEAN	VERBAL INTERPRETATION
The system's hardware parts are easy to reach, fix, or swap if needed.	2.36	Disagree
The software is well-documented and simple to update or change.	2.45	Disagree
The system comes with easy-to-follow guides for fixing common problems.	2.3	Disagree
Regular maintenance can be done without needing expert skills.	2.7	Neutral
The system is designed in a way that makes future upgrade easy without big changes.	2.6	Neutral
Total Overall Mean	**2.48**	**Disagree**

Table 4.6 shows the evaluation questionnaire results for the Maintainability of the evaluation of 5 Admin of Quezon City University San Bartolome Campus. The attributes are "The system's hardware parts are easy to reach, fix, or swap if needed.", "The software is well-documented and simple to update or change.", "The system comes with easy-to-follow guides for fixing common problems.", "Regular maintenance can be done without needing expert skills.", "The system is designed in a way that makes future upgrade easy without big changes.". In total the maintainability of the system based on the evaluation questionnaire given to the admins of QCU at San Bartolome Campus is 2.48 with the verbal interpretation "Disagree".

Table 4.7 Mean, Verbal Interpretation, and Description of the Functional Suitability Based on the Admin Evaluation Questionnaire.

FUNCTIONAL SUITABILITY	MEAN	VERBAL INTERPRETATION
The system consistently operates as intended without unexpected failures.	3.6	Agree
The charging station maintains stable performance under different environmental conditions.	3.75	Agree
The RFID system accurately detects and authenticates user without errors.	3.9	Agree
The system can handle continues usage without experiencing major malfunctions.	3.85	Agree
Does POWERWALK support sustainability energy practices?	4.1	Agree
Total Overall Mean	**3.84**	Agree

Table 4.7 shows the evaluation questionnaire results for the Functional Suitability of the evaluation of 5 Admin of Quezon City University San Bartolome Campus. The attributes are "The system consistently operates as intended without unexpected failures.", "The charging station maintains stable performance under different environmental conditions.", "The RFID system accurately detects and authenticates user without errors.", "The system can handle continues usage without experiencing major malfunctions.", "Does POWERWALK support sustainability energy practices?". In total the Functional Suitability of the system based on the evaluation questionnaire given to the admins of QCU at San Bartolome Campus is 3.84 with the verbal interpretation "Agree".

Table 4.8 Mean, Verbal Interpretation, and Description of the Portability Based on the Admin Evaluation Questionnaire.

PORTABILITY	MEAN	VERBAL INTERPRETATION
The charging station effectively converts kinetic energy into electrical power.	3.45	Agree
The system's design is lightweight and compact enough for transport.	3.55	Agree
The components are modular, making disassembly and reassembly convenient.	3.8	Agree
The system remains fully functional after being moved to a different location.	3.65	Agree
Transporting the system requires minimal specialized tools or equipment.	3.7	Agree
Total Overall Mean	**3.63**	Agree

Table 4.8 shows the evaluation questionnaire results for the Portability of the evaluation of 5 Admin of Quezon City University San Bartolome Campus. The attributes are "The charging station effectively converts kinetic energy into electrical power.", "The system's design is lightweight and compact enough for transport.", "The components are modular, making disassembly and reassembly convenient.", "The system remains fully functional after being moved to a different location.", "Transporting the system requires minimal specialized tools or equipment.". In total the Portability of the system based on the evaluation questionnaire given to the admins of QCU at San Bartolome Campus is 3.63 with the verbal interpretation "Agree".

Table 4.9 Mean, Verbal Interpretation, and Description of the Performance Efficiency Based on the Admin Evaluation Questionnaire.

PERFORMANCE EFFICIENCY	MEAN	VERBAL INTERPRETATION
The charging station effectively converts kinetic energy into electrical power.	4.15	Agree
The system processes user authentication and charging transactions without noticeable delay.	4.43	Agree
The power output is consistent and meets the expected charging capacity.	4.53	Strongly Agree
The system operates efficiently without excessive energy loss or overheating.	4.3	Agree
The response time of the RFID and power management system is optimal for user convenience.	4.5	Agree
Total Overall Mean	**4.37**	Agree

Table 4.9 shows the evaluation questionnaire results for the Performance Efficiency of the evaluation of 5 Admin of Quezon City University San Bartolome Campus. The attributes are "The charging station effectively converts kinetic energy into electrical power.", "The system processes user authentication and charging transactions without noticeable delay.", "The power output is consistent and meets the expected charging capacity.", "The system operates efficiently without excessive energy loss or overheating.", "The response time of the RFID and power management system is optimal for user convenience.". In total the Performance Efficiency of the system based on the evaluation questionnaire given to the admins of QCU at San Bartolome Campus is 4.37 with the verbal interpretation "Agree".

Table 4.10 Mean, Verbal Interpretation, and Description of the Usability Based on the Admin Evaluation Questionnaire.

USABILITY	MEAN	VERBAL INTERPRETATION
The charging station is easy to use, even for first-time users.	3.95	Agree
The user interface and instructions are clear and understandable.	4.05	Agree
Users can easily navigate the RFID authentication process without confusion.	4.25	Agree
Feedback (such as LED indicators or screen messages) is provided to guide users during charging.	4.1	Agree
The system is designed to accommodate a diverse range of users effectively.	4.3	Agree
Total Overall Mean	**4.13**	Agree

Table 4.10 shows the evaluation questionnaire results for the Usability of the evaluation of 5 Admin of Quezon City University San Bartolome Campus. The attributes are "The charging station is easy to use, even for first-time users.", "The user interface and instructions are clear and understandable.", "Users can easily navigate the RFID authentication process without confusion.", "Feedback (such as LED indicators or screen messages) is provided to guide users during charging.", "The system is designed to accommodate a diverse range of users effectively.". In total the Usability of the system based on the evaluation questionnaire given to the admins of QCU at San Bartolome Campus is 4.13 with the verbal interpretation "Agree".

Table 4.11 Mean, Verbal Interpretation, and Description of the Security Based on the Admin Evaluation Questionnaire.

SECURITY	MEAN	VERBAL INTERPRETATION
The RFID system effectively prevents unauthorized access to the charging station.	4.5	Strongly Agree
The system protects user data and prevents unauthorized tampering.	4.4	Agree
Physical security features (such as casing and locks) prevent damage or theft.	4.35	Agree
The system is resistant to common hacking or RFID cloning attempts.	4.2	Agree
Any security breach or malfunction is logged and alerts are provided if needed.	4.55	Strongly Agree
Total Overall Mean	**4.4**	Agree

Table 4.11 shows the evaluation questionnaire results for the Security of the evaluation of 5 Admin of Quezon City University San Bartolome Campus. The attributes are "The RFID system effectively prevents unauthorized access to the charging station.", "The system protects user data and prevents unauthorized tampering.", "Physical security features (such as casing and locks) prevent damage or theft.", "The system is resistant to common hacking or RFID cloning attempts.", "Any security breach or malfunction is logged and alerts are provided if needed.". In total the Security of the system based on the evaluation questionnaire given to the admins of QCU at San Bartolome Campus is 4.4 with the verbal interpretation "Agree".

Table 4.12 Mean, Verbal Interpretation, and Description of the Compatibility Based on the Admin Evaluation Questionnaire.

COMPATIBILITY	MEAN	VERBAL INTERPRETATION
The system fits well with the current setup at Quezon City University.	4.2	Agree
The system does not affect the grid improperly, as well as other components.	4.1	Agree
The RFID correctly tracks the UID (Unique Identification) of each person registered.	4.3	Agree
The system works smoothly in specific areas of the campus without any problems.	4.25	Agree
Total Overall Mean	**4.21**	Agree

Table 4.12 shows the evaluation questionnaire results for the Compatibility of the evaluation of 5 Admin of Quezon City University San Bartolome Campus. The attributes are "The system fits well with the current setup at Quezon City University.", "The system does not affect the grid improperly, as well as other components.", "The RFID correctly tracks the UID (Unique Identification) of each person registered.", "The system works smoothly in specific areas of the campus without any problems.". In total the Compatibility of the system based on the evaluation questionnaire given to the admins of QCU at San Bartolome Campus is 4.21 with the verbal interpretation "Agree".

Criteria	Overall Mean	Verbal Interpretation
Performance Efficiency (Student)	4.37	Agree
Performance Efficiency (Admin)	4.37	Agree
Security (Student)	4.22	Agree
Security (Admin)	4.04	Agree
Usability (Student)	4.36	Agree
Usability (Admin)	4.13	Agree
Compatibility (Student)	4.43	Agree
Compatibility (Admin)	4.21	Agree
Reliability	4.40	Agree
Maintainability	2.48	Disagree
Functional Suitability	3.84	Agree
Total Overall Mean	**4.44**	**Agree**

In Summary, The Powerwalk Station was evaluated by 372 students from Quezon City University San Bartolome Campus, the results indicate strong approval, the highest ratings for efficiency and device compatibility, while security scored slightly lower but remained positive. Students found the system

intuitive, secure for registered users, and highly useful in emergencies. Over all the Powerwalk station proves to be an effective, user-friendly, and reliable charging solution for the students in Quezon City University San Bartolome Campus. And, it was evaluated was evaluated by 5 admins from Quezon City University San Bartolome Campus. The Functionality Suitability (3.84 - agree), Performance Efficiency (4.37 - agree), Usability (4.13, 4.36 - agree), Security (4.04, 4.26- agree), and Compatibility (4.21,4.43 - agree) received positive ratings, Maintainability (2.48 - disagree) was a concern, Portability (3.63 - agree). Overall, the system excels in reliability, security, and user-friendliness of the system.

Chapter 5
SUMMARY, CONCLUSION AND RECOMMENDATION

In this chapter, the proponents of the system include the following: Summary of findings, conclusion, and recommendations.

5.1 Summary of Findings

1. The interview conducted by the researchers to the students, and staffs and guards of QCU San Bartolome highlights the reason on why students aren't allowed to charge in the school campus buildings, the researchers have taken note of the reason of the school administration as it may cause short circuit to the buildings effecting the elevators, the digital records of some buildings, a cause of a fire, etc., because of this student tend to break the policy of the school when faculty members and staff aren't present. This results to students having difficulties when it comes to emergencies, when they need to pass an assignment or research through their depleted phones. To address this issue, implementing or a charging station solely/primarily targeting for the students use, will surely enhance the student's needs.

2. The Powerwalk Charging Station was able to create a dashboard that tracks and displays real-time data on energy generation and consumption, showing how much energy students use.

3. The researchers successfully developed a charging station powered by human footsteps, making it independent from the school's power grid and environmentally friendly. It is exclusively designed for student use.

4. Piezoelectric transducers were effectively used to convert kinetic energy from footsteps into electrical energy. It was calculated that in every 15 minutes of use,

the station can charge a mobile phone by approximately 12%. Factors such as battery health, device usage during charging, and temperature affect charging efficiency.

5. The system uses RFID to restrict access; only registered student IDs can activate the charging function, which is limited to 15-minute sessions.

6. The Powerwalk Station offers three charging ports: USB Lightning, USB-C, and Micro USB, accommodating various device types.

7. The researchers, in alignment with the university's sustainability goals, are pursuing patent and copyright processes to secure rights for future implementation within the campus.

8. Based on the ISO 25010 Software Quality Model, the Powerwalk Station was evaluated by 372 students and 5 administrative staff from Quezon City University San Bartolome Campus. The results revealed that the system performed well across most quality attributes. In terms of functional suitability, it achieved a mean score of 3.84, indicating that it sufficiently met its intended purpose of providing an energy-efficient charging solution. Performance efficiency received a high mean of 4.37, reflecting the system's ability to effectively convert and deliver energy. The usability of the system was also positively rated, with a mean of 4.13, suggesting that students found the interface intuitive and user-friendly. Security was rated at 4.4, showing that the system's access control features for registered users were perceived as reliable. The compatibility attribute scored 4.21, indicating strong adaptability with various devices.

However, a notable concern was raised regarding maintainability, which received a low mean score of 2.48. This suggests potential issues with ease of repair, updating, or ongoing support, which could affect the long-term viability of the system. Portability scored 3.63, showing that while the system is moderately portable, there is still room for improvement in terms of physical mobility and

adaptability to different locations. Overall, the Powerwalk Station attained a total mean score of 4.44, indicating strong agreement on its reliability, usability, and effectiveness as a sustainable charging solution. Despite the identified concern with maintainability, the system demonstrates a promising and practical application of green technology in a campus setting.

5.2 Conclusion

Based on the Findings of the researchers come up with the following conclusions:

1. In conclusion, interviews with students, staff, and guards at QCU San Bartolome revealed that charging is prohibited on campus due to safety concerns, such as risks of short circuits, elevator malfunctions, and potential fires. However, students often charge devices in secret, leading to difficulties during emergencies or when submitting work. Establishing a designated charging station for student use would address these needs while maintaining campus safety.

2. To conclude, the researchers successfully created an eco-friendly charging station powered by human footsteps, eliminating the need for connection to the school's power grid and promoting sustainable energy use. Designed specifically for students, the Powerwalk Charging Station aligns with the university's commitment to innovation and sustainability. To support its long-term implementation, the researchers are actively pursuing patent and copyright protection for the project.

3. To conclude the functionalities of the research, the Powerwalk Charging Station successfully demonstrates the use of piezoelectric technology to convert human footsteps into electrical energy. With real-time energy tracking through a dashboard, controlled access via RFID, and support for various device types through multiple charging ports, the system offers a secure, efficient, and sustainable way for students to charge their devices on campus.

4. The charging system was tested and evaluated by both students and administrators from Quezon City University. Most of them gave positive feedback, especially on how fast, easy, and reliable the system is. Students rated performance efficiency the highest, which means the system responds quickly. Usability and reliability also got good scores, showing that students found it easy to use and it worked without problems. The only concern from the student side was the security part, which means some students are still unsure if their personal mobile device is fully safe in terms of theft.

Administrators also gave good ratings. They were happy with how the system handles data and how secure it is. Performance and security got the highest scores from them. Compatibility and usability were also rated well, meaning the system works fine on different devices and is easy to manage. But they pointed out that the system needs improvements in maintenance and updates.

Maintainability got the lowest score, which shows that fixing bugs updating the system and hardware may be difficult right now.

In terms of technical results, the project used piezoelectric tiles to turn footsteps into electricity. That power is stored in a 12V, 4Ah battery. When a student taps their RFID ID, the system allows them to charge their phone for 15 minutes. Based on our computation, this gives around 10–15% battery increase depending on the phone's battery size. This means even a short charge can help in emergencies or low battery situations during school hours.

Lastly, we calculated the number of steps needed to fully charge the system. With 4 tiles generating 6 watts, it would take about 28,800 steps to fully charge the battery. The more tiles we add, the fewer steps are needed. This shows that the system is more efficient with more tiles, and it proves the concept that, the footsteps can really power mobile devices for students.

5.3 Recommendations

To enhance the functionality and efficiency of Power Walk, the following recommendations are proposed.

1. **Improve Energy Storage Capacity:** Upgrading to a higher-capacity battery or integrating a supercapacitor system can help store more energy and provide a more stable power supply to devices.
2. **Enhance RFID Security:** Implementing encryption for RFID data or switching to NFC authentication could further secure the system against unauthorized access.
3. **Increase System Scalability:** Future implementations should consider installing additional piezoelectric tiles in high-foot-traffic areas to maximize energy generation.
4. **Durability of Piezo Tiles**: The Future researchers should consider the material for the production of the piezo tiles.
5. **Enhance System Maintainability:** Improve hardware accessibility to make repairs and part replacements easier. Develop detailed maintenance guides for both hardware and software updates.

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APPENDICES

APPENDIX A - GANTT CHART

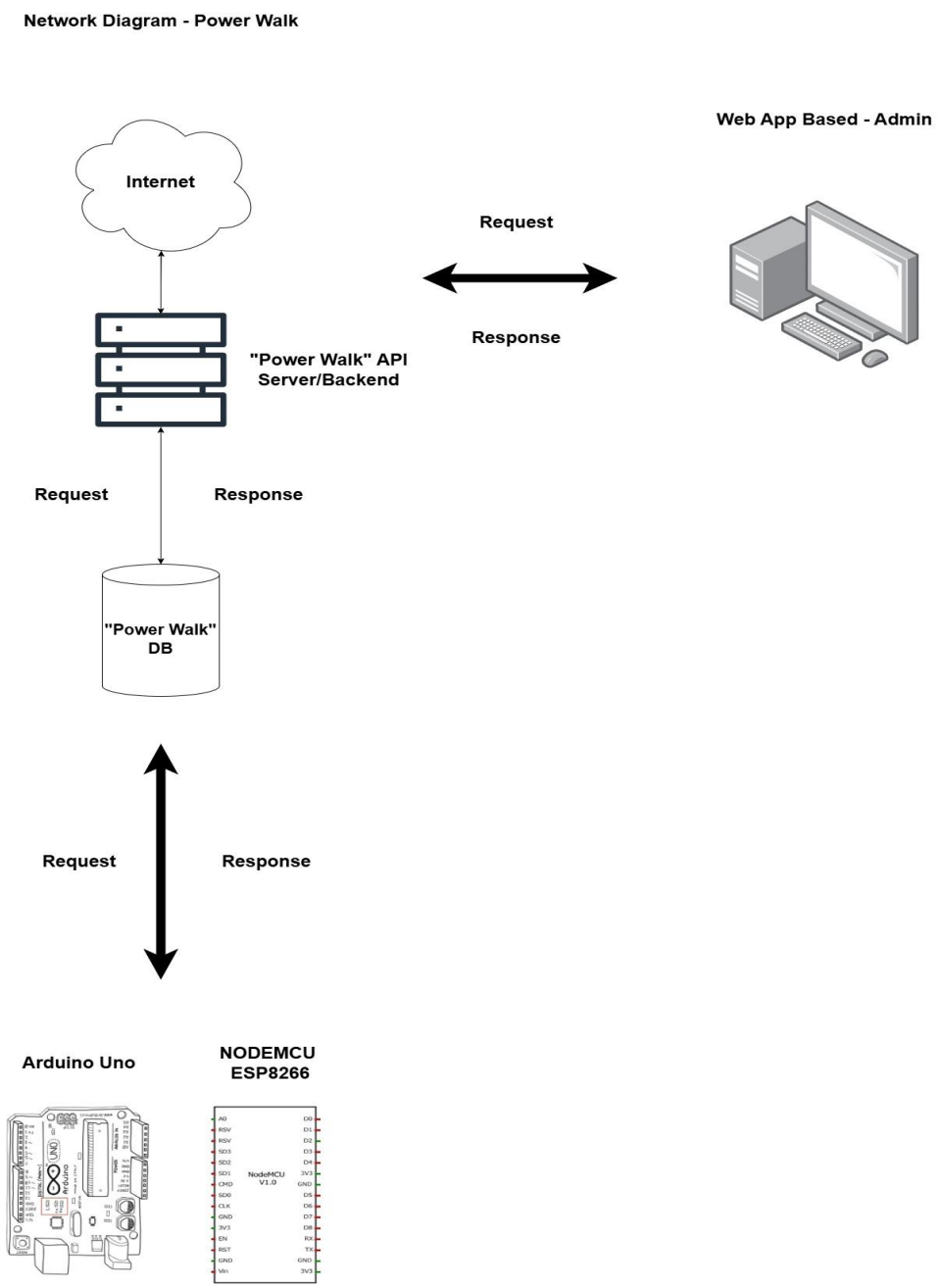
Project Name: "Power Walk": Converting Foot Traffic into Electricity using Piezoelectric Sensors and Arduino Uno with RFID for Quezon City University
Project Start: October 05, 2024
Project End: March 10, 2025

GANTT CHART

TASKS AND ACTIVITIES	TIMEFRAME WEEK#																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. Requirements Gathering and Analysis																							
a. Conduct analysis of energy generation needs, expected foot traffic, power storage and user requirement																							
b. Document system features, including RFID-based access control.																							
2. System Design and Architecture																							
a. Design overall system architecture																							
b. Define the data flow for RFID authentication and power monitoring.																							
3. Software Development and Implementation																							
a. Develop Arduino code for RFID authentication, power monitoring, and data logging.																							
b. Implement a user interface for monitoring energy usage.																							
c. Integrate software with hardware.																							
4. Hardware Development and Testing																							
a. Assemble and test piezoelectric tiles, rectifiers, capacitors, and battery storage																							
b. Ensure proper integration with the charging station.																							
b. Ensure proper integration with the charging station.																							
5. System Testing																							
a. Conduct full-scale tests:																							
b. Verify power efficiency, test RFID access																							
c. Monitor charge output, and conduct stress tests on piezoelectric tiles																							
6. Deployment and User Training																							
a. Install the charging station at Quezon City University.																							
b. Conduct user training for students and faculty on RFID authentication and charging procedures.																							
7. System Evaluation and Documentation																							
a. Evaluate energy efficiency, user feedback, and overall system performance.																							
b. Document system design, user manuals																							
c. Recommendations for future improvements																							

APPENDIX B

NETWORK LAYOUT



APPENDIX C

SYSTEM EVALUATION QUESTIONS

SURVEY EVALUATION (ADMIN SIDE)

A. Functional Suitability
1. The system consistently operates as intended without unexpected failures.
2. The charging station maintains stable performance under different environmental conditions.
3. The RFID system accurately detects and authenticates users without errors.
4. The system can handle continuous usage without experiencing major malfunctions.
5. Does POWERWALK support sustainable energy practices?

B. Performance Efficiency
1.The charging station effectively converts kinetic energy into electrical power.
2. The system processes user authentication and charging transactions without noticeable delay.
3. The power output is consistent and meets the expected charging capacity.
4. The system operates efficiently without excessive energy loss or overheating.
5. The response time of the RFID and power management system is optimal for user convenience.

C. Compatibility
1. The system fits well with the current setup at Quezon City University.
2. The piezoelectric tiles work properly, as well as other components.
3. The RFID correctly tracks the UID (Unique Identification) of each person registered.
4. The system can be easily improved in the future.
5. The system runs smoothly in specific areas of the campus without any problems.

D. Usability
1. The charging station is easy to use, even for first-time users.
2. The user interface and instructions are clear and understandable.
3. Users can easily navigate the RFID authentication process without confusion.

4. Feedback (such as LED indicators or screen messages) is provided to guide users during charging.
5. The system is designed to accommodate a diverse range of users effectively.

E. Security
1.The RFID system effectively prevents unauthorized access to the charging station.
2. The system protects user data and prevents unauthorized tampering.
3. Physical security features (such as casing and locks) prevent damage or theft.
4. The system is resistant to common hacking or RFID cloning attempts.
5. Any security breach or malfunction is logged and alerts are provided if needed.

F. Maintainability
1. The system's hardware components are easy to access, repair, or replace if needed.
2. The software (Arduino-based system) is well-documented and easy to update or modify.
3. The system includes clear troubleshooting guides for common issues.
4. Routine maintenance can be performed with minimal technical expertise.
5. The overall system design allows for future upgrades without major rework.

G. Portability
1.The charging station effectively converts kinetic energy into electrical power.
2. The system's design is lightweight and compact enough for transport.
3. The components are modular, making disassembly and reassembly convenient.
4. The system remains fully functional after being moved to a different location.
5. Transporting the system requires minimal specialized tools or equipment.

SURVEY EVALUATION (STUDENT SIDE)
A. Performance Efficiency
1. Does the Powerwalk Station quickly charge your device?
2. Is the Powerwalk Station efficient in how it works?
3. Does the Powerwalk Station perform well for students?

B. Security
1. Does the Powerwalk Station allow only registered student IDs to charge?
2. Does the Powerwalk Station block unregistered IDs from charging?
3.Do you feel that your device is safe while using the Powerwalk Station?

C. Usability
1. Is the Powerwalk Station easy to use for charging?
2. Is it easy to check how much charging time is left for students?
3. Can you understand how to use the Powerwalk Station without needing help?

D. Reliability
1. Is the Powerwalk Station helpful in emergencies? (e.g., charging for submitting an assignment or making an urgent call/text)
2. Does the Powerwalk Station encourage students to use it?
3. Is 15 minutes enough for an emergency charge?

E. Compatibility
1. Does the Powerwalk Station work with your mobile device?
2. Does the Powerwalk Station provide the right port for your device?
3. Can you charge different types of devices using the Powerwalk Station?

APPENDIX D

TRANSCRIPT OF INTERVIEW

This chapter includes the answers given to the interviewed QCU Students and QCU staff of Quezon City University at San Bartolome Campus.

4.1 Questions and Answers

Students

Quezon city university students (Monday morning schedule)

Q: What device do you often use for studying?

A: *Phone po lagi yung ginagamit namin dahil kahit san pong website or ano man gusto naming gawin nagagawa naming sa phone, tsaka mas madali po dalhin dahil ibubulsa nalang po.*

Q: How often does your device get drained? A day?

A: *Once lang po na d-drained, dahil nag f-full charged naman po kami sa bahay before pumunta sa school, depende nalang po if hanggang gabi schedule namin sa school. O kaya kapag wala pong school once lang din po.*

Q: How frequently do you charge your device(s) a day?

A: *1-2 times a day lang, dahil like I said po kanina f-full charged yung phone before umalis para sa school, and hindi rin po mabilis ma drain yung phone ko*

Q: Have you heard about piezoelectric technology being used to generate electricity?

A: *Hindi pa po, hindi ko nga po alam na may ganyan na word.*

Q: On a scale of 1-5 how interested are you in renewable energy solutions that generate electricity from human foot traffic?

A: *I rate 5 po as super interesado po ako, dahil po if i-imagine ko perfect etong konsepto nyo sa mga matataong lugar at makakatulong talaga to' sa society natin.*

Q: Do you think having an eco-friendly and cost-efficient source of electricity can be beneficial to schools or other companies?

A: *Yes, naiisip ko po na makakatipid talaga siya ng kuryente lalo na sa mga malalaking company and sa school natin.*

Q: Do you charge your devices inside the school premises?

A: *Yes po, madalas kailangan ko rin mag full battery kapag hindi po nakapag full charged sa bahay. Dahil ginagamit ko palagi phone ko for assignment, sa pag research and especially po sa communications po.*

Q: Are you aware that it is forbidden to charge your electrical devices at QCU?

A: *Yes po, pero no choice din naman po ako and nakakapag charge naman po ako ng patago or kapag wala po yung professor naming.*

Q: Do you suggest having a charging station at QCU?

A: *Yes naman po, para hindi na kami masuway or mahuli na nag charge and I think marami po talaga gagamit ng charging station.*

Q: Are you willing to take part in the beta-testing of our system

A: *Yes, surely po!*

Staffs (Guards, Maintenance team in Restrooms)

Q: What personal Device do you often use when you are on duty?

A: Cellphone, mandalas kasi kapag may mga reports na gagawin kaming need i pasa sa phone kami gumagawa.

Q: How often does your device get drained a day?

A: Isang beses lng, pero dipende maam kapag may events sa school or may activities may mga time na gumagawa kami ng activities, dun kami na dradrain ng battery.

Q: How often do you charge your device a day?

A: Isa or kaya dalawang beses

Q: Where do you charge your device?

A: Sa Station namin maam kung saan kami naka assign, kasi maam every 3 days nagpapalit kami lhat ng station, kunwari ngayon nandun ako sa acad building after 3 days nasa admin building naman ako. Pero may mga station kami na walang malapit na saksakan maam kaya sa admin kami nag chacharge or sa bahay na lang.

Q: Are there restrictions or places you are not allowed to charge your device? If yes where?

A: Wala naman maam, pwede naman kami mag charge as staffs sa QCU.

Q: Why are students not allowed to charge in the school buildings?

A (Guard of Admin Building): *Unang una maam dahil dito sa lobby kapag pinayagan namin ung isa dyan, gagaya at gagaya ung iba, tsaka ang kautusan samin ng ka taas taasan ay, pagbawal mga studyante mag saksak dahil kpag nagsabay sabay sila nag saksak may possibilidad na magka short circuit. Lalong lalo na Admin building to, nandito ung mga records, ung office ng president, bawal magka problema sa kuryente dito. Pero kapag nakiusap na emergency, papayag naman kami, basta bantayan ung gamit at hindi tatagal ng isang oras kung emergency tlga.*

A (Guard Of Belmonte Building): *Ang utos po kasi samin, bawal mag saksak lalo na kpag students kasi gagayahin na ng iba kapag pinayagan namin ung isa. Tsaka po dipende sa na building papasukan, lalo na ung mga public na sockets ung mga nasa hallway, bawal na bawal po dyan kasi napaka daming studyante sa qcu tsaka sa building dito, kpag sabay sabay sila mag charge baka mag short circuit. Pati na rin sa canteen, bawal din po mag charge dyan.*

A (Guard of Academic Building): *Bawal po tlga lalo na po ung mga sockets dito sa lobby, Kasi magkaka problema po kapag nag short circuit, may possibilidad na madamay damay ung ibang part ng building lalo na may Elevator dito sa building na to.*

A (Guards of Bautista Building): *Bawal po kasi, usually ang ginagawa, iniiwan po ung gamit baka maging cause to ng sunog, at sinabihan din kami ng mga nasa taas na, bawal po mag saksak ung mga studyante dahil ung building na to laboratory, madaming devices nandito, may mga PC dito na pwede madamay kapag nag ka short circuit. Pero kapag nakikiusap sila na may need ipasa or emergency na may need tawagan, pumapayag naman kami, binibigyan namin sila madalas ng 15 minutes para makapag charge.*

Q: Do you suggest having a charging station at QCU?

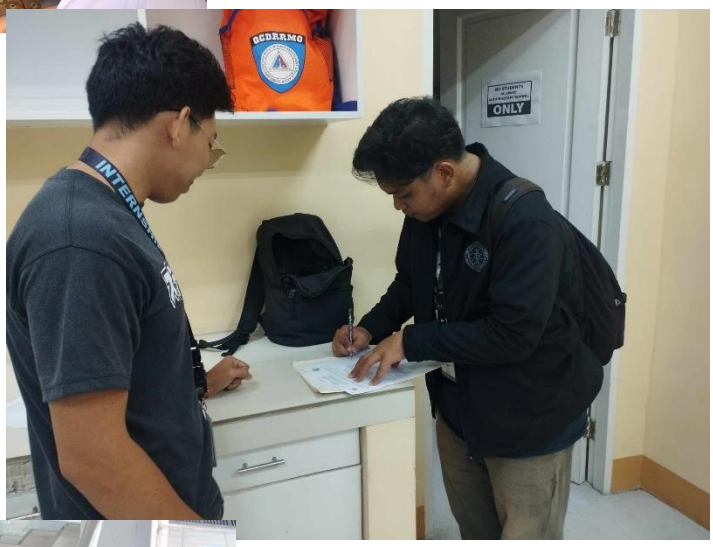
A: Oo naman, necessity yan para for communication, tsaka para sa mga tao dito sa campus ng QCU, at lahat ng tao dito gumagamit na ng phone, Lalong lalo na para sa emergency.

APPENDIX E

PHOTO DOCUMENTARY DURING SYSTEM EVALUATION

POWER WALK

center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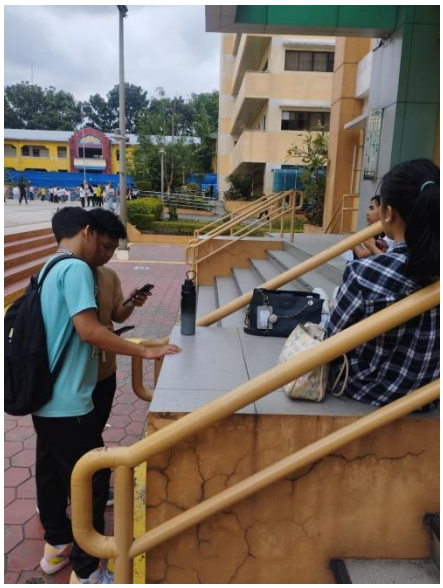
APPENDIX F

PHOTO DOCUMENTARY DURING DATA GATHERING



APPENDIX G

SYSTEM SOURCE CODE

HARDWARE SOOURCE CODE

```
// NODEMCU.ino

#include <Wire.h>

#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>


#define SCREEN_WIDTH 128

#define SCREEN_HEIGHT 64


Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, -1);


#define SS_PIN 0  //D2

#define RST_PIN 2 //D1


#include <SPI.h>

#include <MFRC522.h>


MFRC522 mfrc522(SS_PIN, RST_PIN); // CREATE MFRC522 INSTANCE.
```

```
int statuss = 0;

int out = 0;


#include <SPI.h>

#include <Wire.h>


#include <SoftwareSerial.h>

#include <ESP8266WiFi.h>

#include <ESP8266HTTPClient.h>

#include <WiFiClientSecureBearSSL.h>


const char* ssid = "Jacobe Family";

const char* password = "b@w@lk0m0n3k";


int battery = 0; // VARIABLE TO STORE THE SOUND VALUE

float previousVoltage = 0;


const int relay = 16;

const char* serverName =

"https://192.168.100.5/powerwalksystem/server.php";
```

```
unsigned long timerStart = 0; // TO STORE THE START TIME OF THE
TIMER
unsigned long timerDuration = 10000; // TIMER DURATION IN
MILLISECONDS (E.G., 10000 MS = 10 SECONDS)
bool timerStarted = false; // FLAG TO CHECK IF THE TIMER WAS
STARTED
unsigned long elapsedTime = 0; // VARIABLE TO STORE ELAPSED TIME

// const int batteryPin = A0; // ADC PIN CONNECTED TO BATTERY
VOLTAGE
// const float fullBatteryVoltage = 12.8; // EXAMPLE FOR A LI-ION
BATTERY

const int batteryPin = A0; // ADC PIN CONNECTED TO BATTERY
VOLTAGE
const float voltageDividerRatio = 4.78; // ADJUST THIS BASED ON YOUR
VOLTAGE DIVIDER CIRCUIT
const float referenceVoltage = 3.3; // NodeMCU ADC REFERENCE
VOLTAGE
```

```
// float getBatteryPercentage(float voltage) {
//     if (voltage >= 12.6) return 100;
//     else if (voltage >= 12.5) return 90;
//     else if (voltage >= 12.42) return 80;
//     else if (voltage >= 12.32) return 70;
//     else if (voltage >= 12.2) return 60;
//     else if (voltage >= 12.06) return 50;
//     else if (voltage >= 11.9) return 40;
//     else if (voltage >= 11.75) return 30;
//     else if (voltage >= 11.58) return 20;
//     else if (voltage >= 11.31) return 10;
//     else return 0;
// }


float getBatteryPercentage(float voltage) {
   // VOLTAGE TO CAPACITY MAPPING FOR a 12V LEAD-ACID
BATTERY
   const float voltagePoints[] = {10.5, 11.31, 11.58, 11.75, 11.9, 12.06, 12.2, 12.32,
12.42, 12.5, 12.6};
   const float capacityPoints[] = {0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100};
```

```
    // ENSURE THE VOLTAGE IS WITHIN THE VALID RANGE
    if (voltage <= voltagePoints[0]) return 0; // BBELOW MINIMUM
VOLTAGE
    if (voltage >= voltagePoints[10]) return 100; // ABOVE MAXIMUM
VOLTAGE

    // FIND THE INTERVAL WHERE THE VOLTAGE LIES
    int i = 0;
    while (voltage > voltagePoints[i + 1]) {
        i++;
    }

    // LINEAR INTERPOLATION
    float percentage = capacityPoints[i] + (voltage - voltagePoints[i]) *
(capacityPoints[i + 1] - capacityPoints[i]) / (voltagePoints[i + 1] -
voltagePoints[i]);

    return percentage;
}
```

```
// ADD THE AVERAGING FUNCTION HERE
int getAverageADCReading(int pin, int samples = 10) {
  int sum = 0;
  for (int i = 0; i < samples; i++) {
    sum += analogRead(pin);
    delay(300); // SHORT DELAY BETWEEN READINGS
  }
  return sum / samples;
}

void setup()
{
 Serial.begin(115200); // INITIATE A SERIAL COMMUNICATION
 display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
 display.clearDisplay();
 WiFi.begin(ssid, password);
 Serial.println("Connecting");
 while(WiFi.status() != WL_CONNECTED) {
  delay(500);
```

```
Serial.print(".");
```

SYSTEM SOURCE CODE

power-walk-api

- src/repositories/RFIDRepository.ts
- src/services/RFIDService.ts
- src/controllers/RFIDController.ts
- src/repositories/HardwareRepository.ts
- src/services/HardwareService.ts

-src/controllers/HardwareController.ts

- src/utils/ejs/sendAccountDetails.ejs
- src/utils/sendAccountDetails.ts
- .env

```
// prisma/schema.prisma

generator client {

  provider = "prisma-client-js"

}


datasource db {

  provider = "mysql"

  url      = env("DATABASE_URL")

}


model account {

  id        Int       @id @default(autoincrement())

  password  String

  adminId   Int?

  createdAt DateTime  @default(now())

  updatedAt DateTime  @updatedAt

  deletedAt DateTime?

  admin     admin?    @relation(fields: [adminId], references: [id])

}
```

```
model admin {
  id        Int       @id @default(autoincrement())
  firstname String
  lastname  String
  email     String
  createdAt DateTime  @default(now())
  updatedAt DateTime  @updatedAt
  deletedAt DateTime?
  role      String    @default("Admin")
  account   account[]
}

model battery {
  id                 Int       @id @default(autoincrement())
  batteryPercentage String?
  batteryVoltage    String?
  createdAt         DateTime  @default(now())
  updatedAt         DateTime  @updatedAt
  deletedAt         DateTime?
}
```

```
model electricity {
  id                    Int       @id @default(autoincrement())
  electricityConsumption String?
  electricityGenerated   String?
  totalHours            Decimal?  @db.Decimal(10, 2)
  createdAt             DateTime  @default(now())
  updatedAt             DateTime  @updatedAt
  deletedAt             DateTime?
}

model electricity_meter {
  id                        Int       @id @default(autoincrement())
  dailyElectricityGenerated   Decimal?  @db.Decimal(10, 2)
  dailyElectricityConsumption Decimal?  @db.Decimal(10, 2)
  createdAt                 DateTime  @default(now())
  updatedAt                 DateTime  @updatedAt
  deletedAt                 DateTime?
}
```

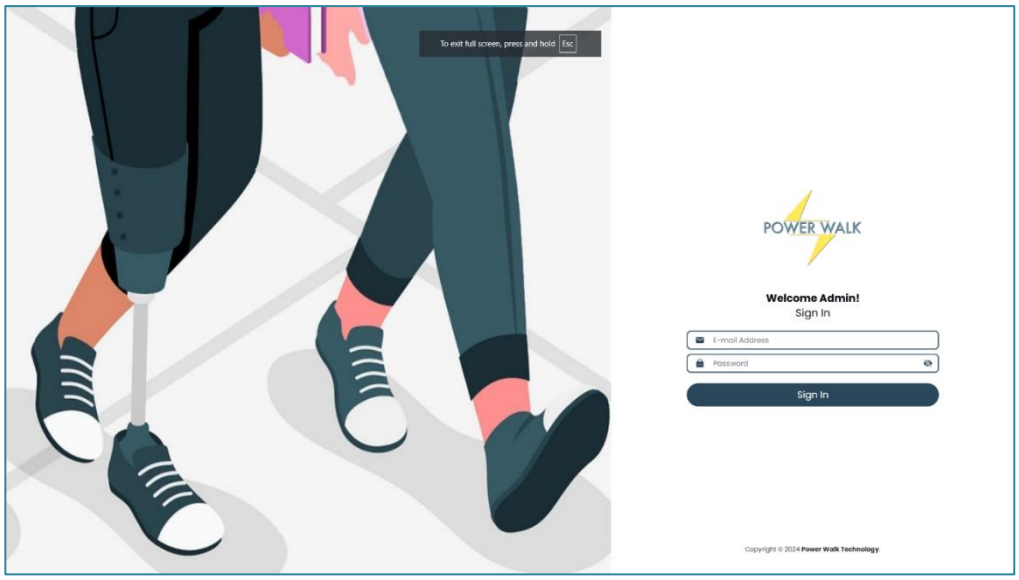
```
model history {
  id        Int    @id @default(autoincrement())
  uid2      String @db.Text
  date_added String @db.Text
}

model rfid {
  id        Int       @id @default(autoincrement())
  uid       String
  createdAt DateTime  @default(now())
  updatedAt DateTime  @updatedAt
  deletedAt DateTime?
}

model student {
  id         Int       @id @default(autoincrement())
  uid        Int
  studentId  String
  firstname  String
  lastname   String
```

```
  middlename  String?
  email       String
  dateOfBirth DateTime
  address     String
  createdAt   DateTime  @default(now())
  updatedAt   DateTime  @updatedAt
  deletedAt   DateTime?
}
```

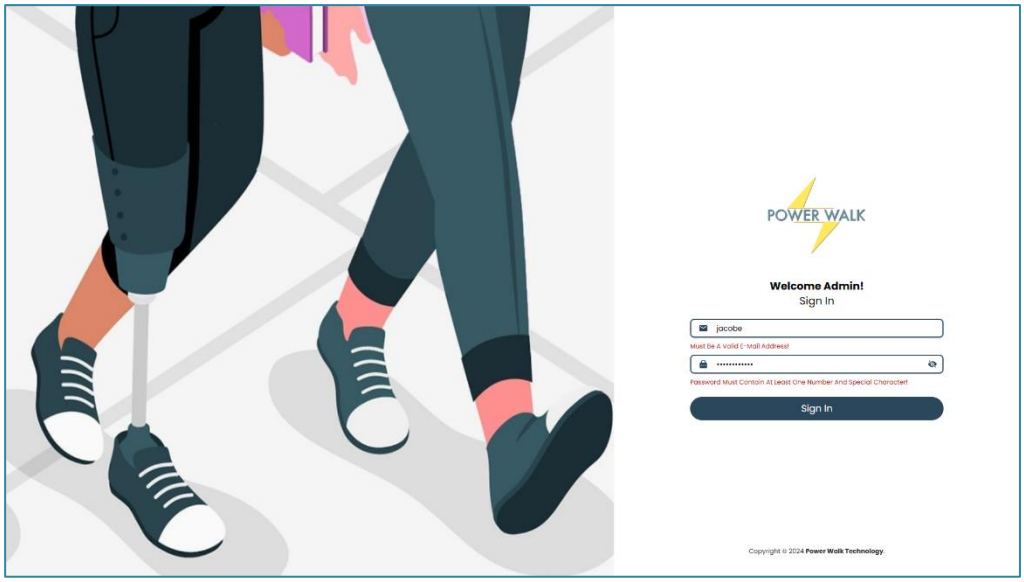
APPENDIX H

SYSTEM SCREENSHOTS

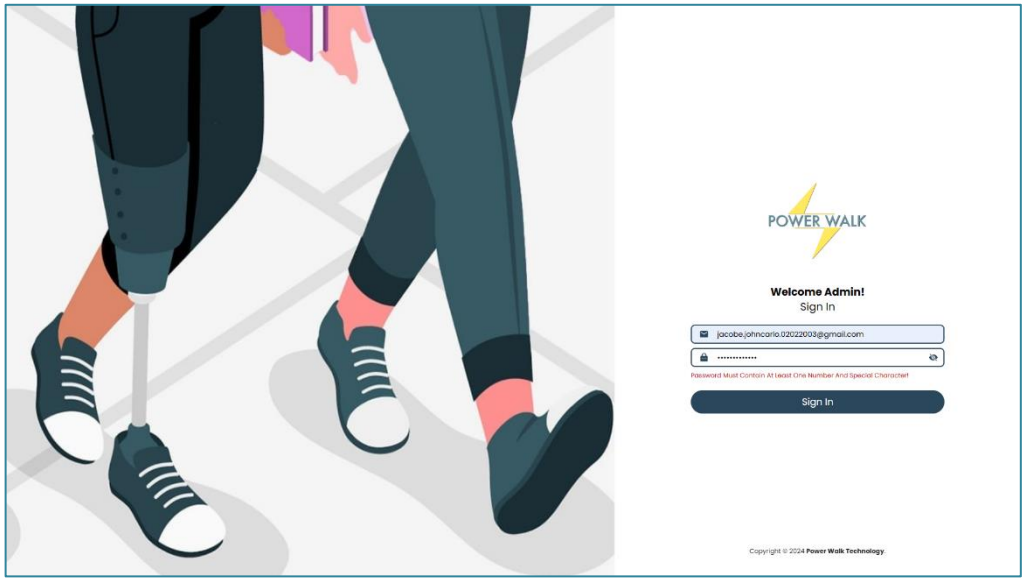
LOG IN PAGE



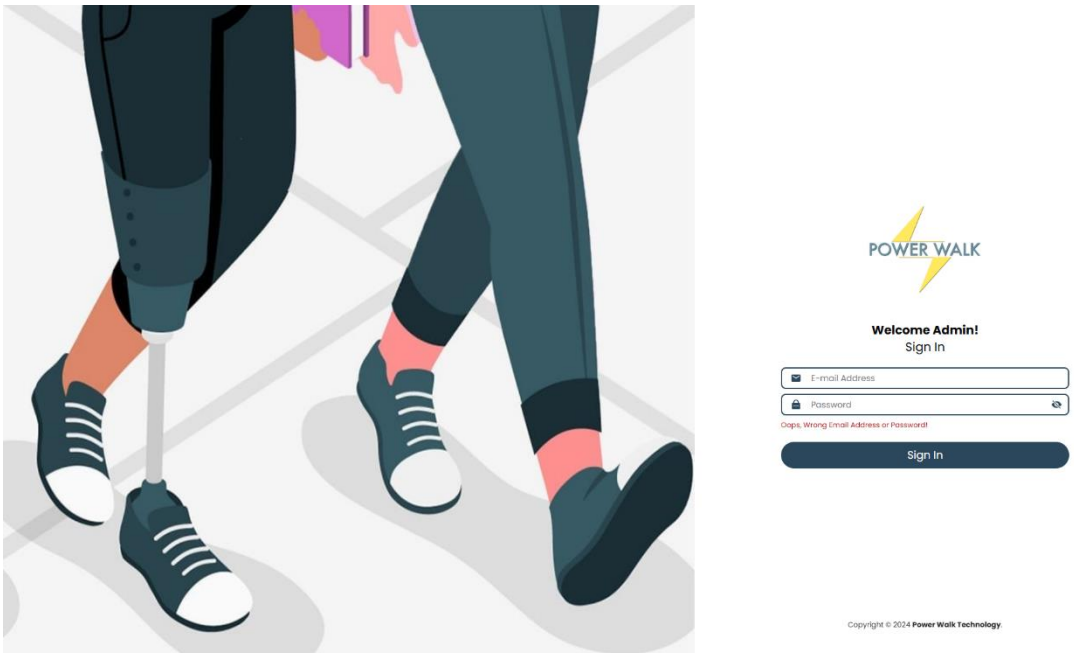
LOG IN PAGE (WRONG CREDENTIALS – MUST BE VALID EMAIL ADDRESS)



LOG IN (WRONG CREDENTIALS – PASSWORD MUST CONTAIN SPECIAL CHARACTER)



LOG IN (WRONG CREDENTIALS – WRONG EMAIL OR PASSWORD)



ADMIN DASHBOARD

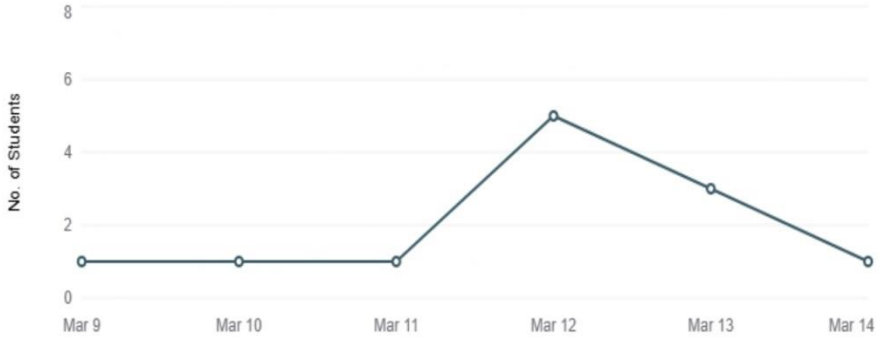
PRINT GENERATED REPORTS

Mechanical Energy Charging Station from Footsteps

POWER WALK

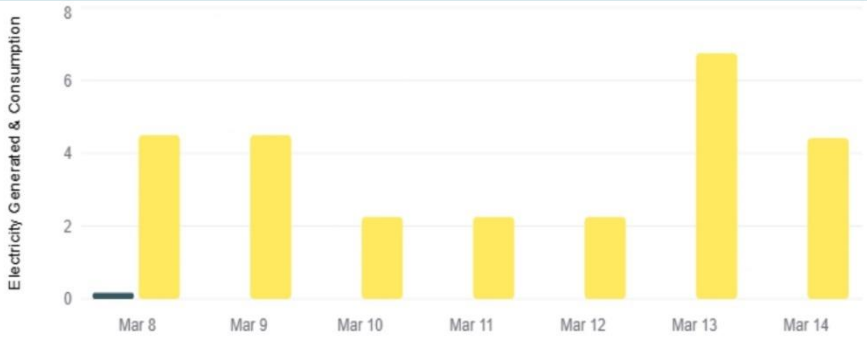
Date: Mar 17, 2025

Daily Usage - Number of Students Per Day



Date	Number of Students
March 9, 2025	1
March 10, 2025	1
March 11, 2025	1
March 12, 2025	5
March 13, 2025	3
March 14, 2025	1

Electricity Generated and Consumption Per Day

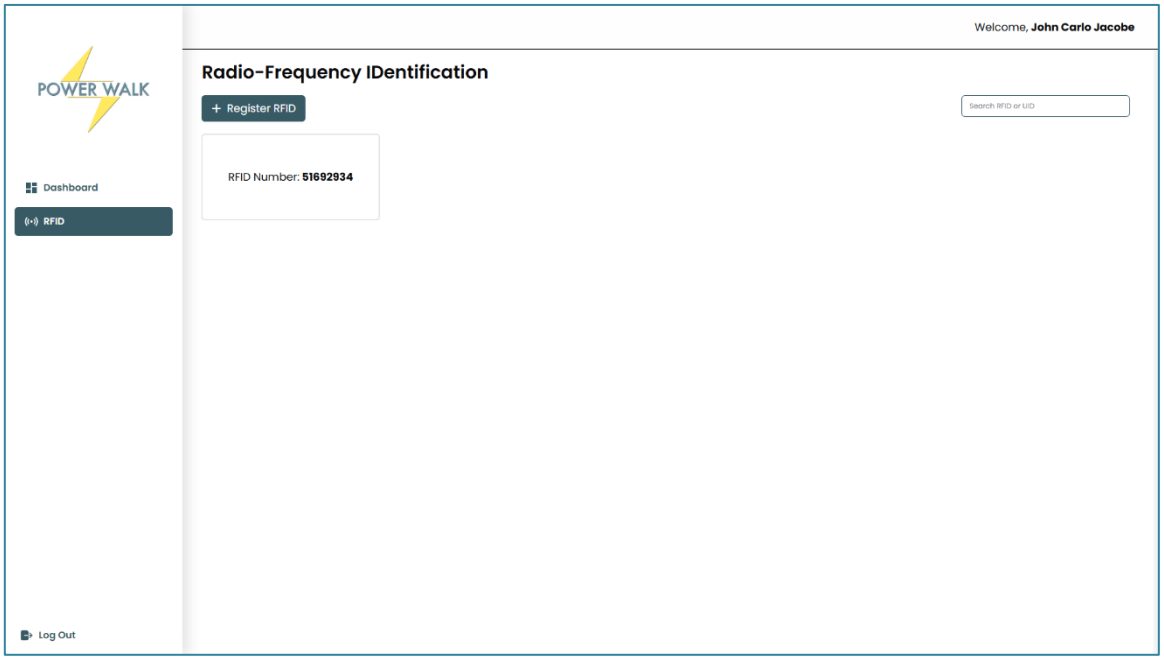


Date	Electricity Generated (V)	Electricity Consumption (Wh)
March 8, 2025	0.16999999999999998	4.5
March 9, 2025	0	4.5
March 10, 2025	0	2.25
March 11, 2025	0	2.25
March 12, 2025	0	2.25
March 13, 2025	0	6.75
March 14, 2025	0	4.42

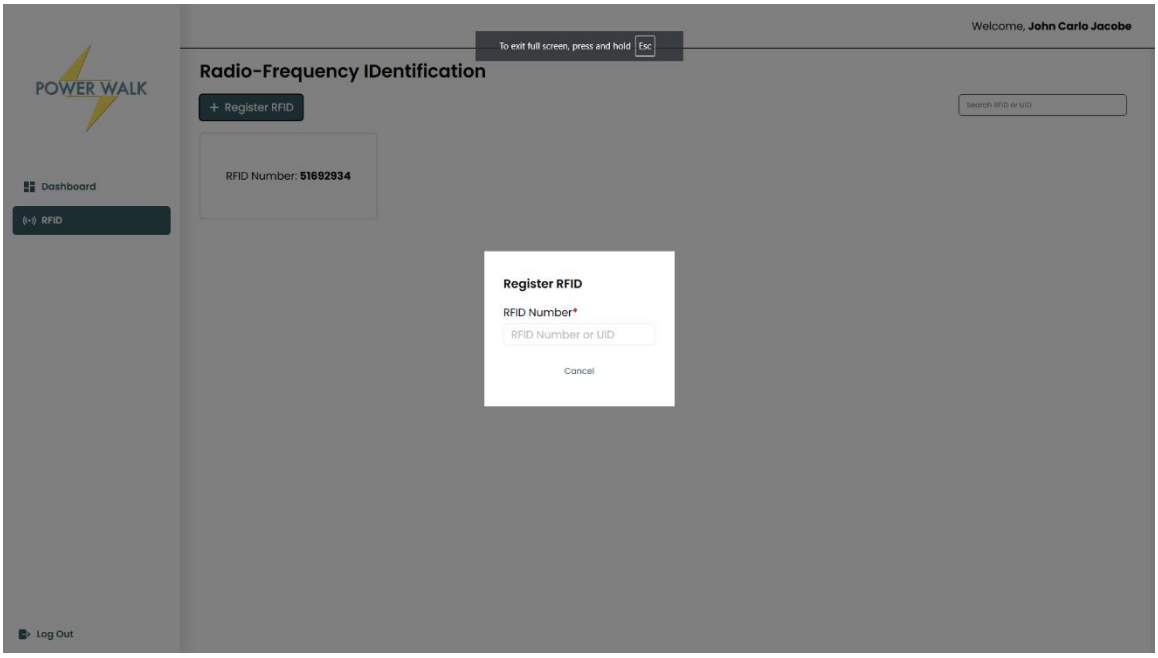
Summary

Total Students	Total Electricity Generated (V)	Total Electricity Consumed (Wh)
12	0.17	26.92

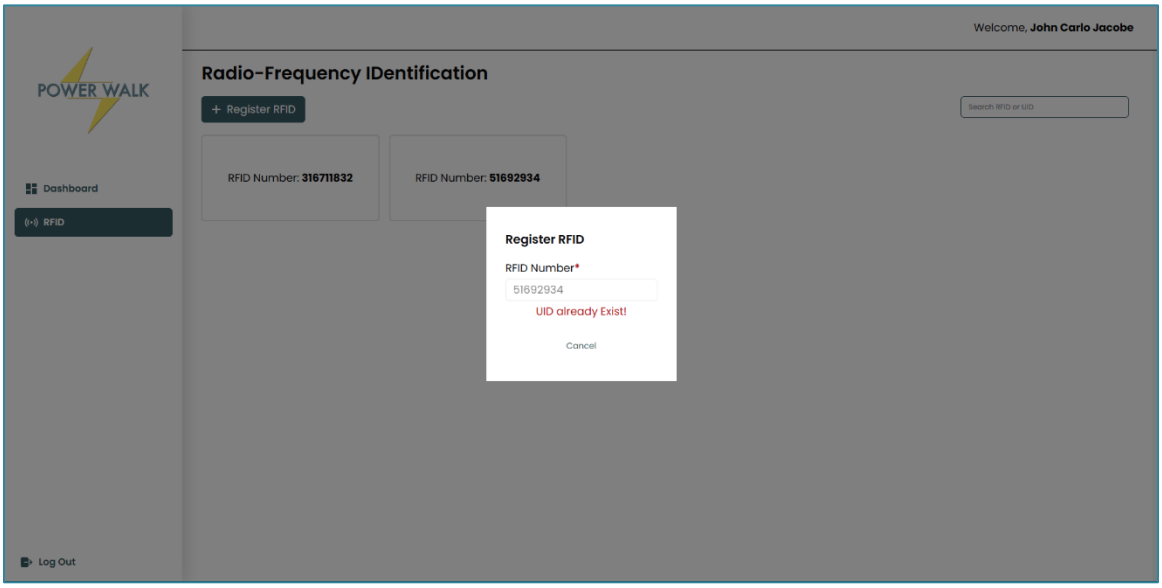
REGISTERED RFID PAGE



REGISTER RFID WINDOW



REGISTERED RFID PAGE (ALREADY EXISTING UID)



APPENDIX I

LETTER FOR CONSULTATION

QUEZON CITY UNIVERSITY
COLLEGE OF COMPUTER STUDIES
673 Quirino Highway, San Bartolome, Novaliches, Quezon City

April 24, 2025

Dear Mr. Ramon L. Raymundo III:

The Fourth-year students of the Bachelor of Science in Information Technology program have recently completed a capstone project entitled **"POWERWALK": CONVERTING FOOT TRAFFIC INTO SUSTAINABLE ENERGY, UTILIZING PIEZOELECTRIC TRANSDUCERS WITH RFID AND DATA VISUALIZATION FOR EFFICIENT POWER GENERATION"** the project aims to harvest kinetic energy and convert it to mechanical energy to power the charging station using Piezoelectricity for student mobile charging at QCU of San Bartolome.

The researchers seek your kind approval to conduct a consultation in regards of the approximate time duration of the project of the Powerwalk, when it comes to implementing it to the school grounds.

In line with this, I kindly request your permission to transcribe your answers and include it in our research documentation.

I would greatly appreciate your support and approval for this initiative, and I am available to discuss any details or concerns you may have regarding the process.

Respectfully,

Lois Meek L. Fernandez
Project Manager

Mr. Ramon L. Raymundo III
Computer Engineer

Rose Anne A. Tanjente, MSIT
Adviser, Capstone Project and Research 2

APPENDIX J

CERTIFICATION OF SAFETY COMPLIANCE

CERTIFICATION OF SAFETY COMPLIANCE

I, Ramon L. Raymundo III, a computer engineer, hereby certify that I have reviewed and assessed the design, construction, and installation of the piezoelectric transducer system developed by the proponents of the capstone project titled **"POWERWALK":** CONVERTING FOOT TRAFFIC INTO SUSTAINABLE ENERGY, UTILIZING PIEZOELECTRIC TRANSDUCERS WITH RFID AND DATA VISUALIZATION FOR EFFICIENT POWER GENERATION."

This assessment focused on evaluating the following considerations:

Load-bearing Capacity - Evaluated the mechanical integrity and verified that the platform can safely support human foot traffic.

Electrical Safety - Operates within safe voltage and current levels as per standard low-power electronic devices.

Safety - Has been built with non-hazardous and durable materials, ensuring both electrical and physical safety during usage.

User Interaction - Assessed the user interaction design to confirm safe and easy operation with RFID access.

Based on the results of these evaluations, I conclude that the piezoelectric transducer system complies with basic safety standards for academic prototype use. It is safe to walk through and operate under normal usage conditions as intended in the design.

Certified by:
Mr. Ramon L. Raymundo III

APPENDIX K

CURRICULUM VITAE

Vincent Arella

Software and Hardware Developer

About Me

Detail-oriented and dedicated Quality Assurance student with a strong passion for ensuring high-quality standards in software development. Gaining hands -on experience in both manual and automated testing.

Contact

vincentarella25@gmail.com

#108 Kilyawan St. Brgy Sta. Monica Novaliches Quezon City

+639606329841

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

OUR LADY OF FATIMA UNIVERSITY

2019 - 2021

Computer Skills

- Automation
- API Testing
- Bug Tracking

Ian Benjamin Bibat

Documentation and Hardware Developer

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

JUDGE FELICIANO BELMONTE SENIOR HIGH SCHOOL

2019 - 2021

About Me

I consider myself a responsible and orderly person. I am looking forward to my first work experience

Contact

bibat.ianbenjamin.11112002@gmail.com

32 Airforce Road Holy Spirit Quezon City

+639926027712

Computer Skills

- IT Support
- Infographics

Jefferson Bustamante

Documentation

About Me

I want to become enthusiastic IT student with a strong foundation in hardware and networking, seeking an opportunity to apply technical skills and gain hands - on experience in a dynamic tech environment

Contact

bustamante.jefferson.11172002@gmail.com

#152 Area 6B Sitio Cabuyao Brgy. Sauyo Quezon City

09395299786

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

ST. CLARE COLLEGE OF CALOOCAN

2019 - 2021

Computer Skills

- Computer Assembly
- Networking

Jeremiah Espeña

Documentation

About Me

I consider myself a responsible and eager to learn some programming that will enhance my foundation skills on software development and front-end. Willing to adapt on any environment as long as I can grow on my skills as 4th year IT student.

Contact

spena.jeremiah.12112002@gmail.com

93-34 Bahay Toro, Mindanao Avenue Quezon City.

09761729064

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

DR. CARLOS S. LANTING COLLEGE

TVL - ICT

2019 - 2021

HOPE CHRISTIAN ACADEMY

2014 - 2018

Computer Skills

- Programming
- Software Developer
- Front- end

Christian Esperanzate

Documentation

About Me

A dedicated and detail-oriented 4th-year IT student with a strong foundation in programming, system analysis, and hardware integration. Seeking an opportunity to apply technical skills and problem-solving abilities in a dynamic IT environment.

Contact

fernandez.loismeek.07072003@mail.com

#59 A Fort Santiago St. Bago Bantay Brgy. Alicia Quezon City

+639474683401

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

COLLEGE OF ST. CATHERINE

2019 - 2021

Computer Skills

- Programming
- Software Developer
- Microsoft Office Apps

Kiesha Mel Estonactoc

Documentation

About Me

Tech-savvy IT student with a passion for problem-solving, and exploring emerging technologies.. A quick learner with a strong ability to adapt and collaborate in team environments. Always eager to work on innovative projects and expand my technical skill set.

Contact

estonactoc.kiesha.10012002 @gmail.com

8 road 10 Bagong Pag Asa Quezon City

09276356927

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

GARDER COLLEGE DILIMAN

Accountancy Business and Management

2019 - 2021

ERNESTO RONDON HIGH SCHOOL

2014 - 2019

Computer Skills

- Microsoft Office Proficiency
- Presentation
- Front- end

Jhun Rey Evangelista

Software and Hardware Developer

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

GARDNER COLLEGE DILIMAN

ICT

2020 - 2021

BALINGASA HIGH SCHOOL

2014 - 2019

About Me

I want to increase my knowledge and capacity about the programming.

Contact

evangeiistajhunrey12.19.2002@gmail.com

1076 int. A. Bonifacio Brgy. Balingasa, Balintawak, Quezon CIty.

0938 829 1613

Computer Skills

- Full Stack Developer

Aaron Urich Fabia

Documentation

About Me

I want to increase my knowledge about technology and integration in this evolving world.

Contact

fabia.aaron.03292003@gmail.com

#1 North St. Don Enrique Village, Brgy. Nagkaisang Nayon, Novaliches, Quezon City

+639934260890

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

OUR LADY OF FATIMA UNIVERSITY

2019 - 2021

GRACE MONTESSORI SCHOOL OF NOVALICHES

2014 - 2019

Computer Skills

- Front- end
- 3D Design

Lois Meek Fernandez

Project Manager

About Me

I always wanted to lead people as I saw it as my strength, gaining trust and knowing different people made me gain a lot of experience and knowledge from being surrounded by them everyday. It also became my fuel to strive for more than I already have. As someone who always wanted to be part of this field, I believe that thru my experience as a leader, it can be a tool for me to other opportunities that would come my way. A straightforward, meticulous person who strives for perfection.

Contact

fernandez.loismeek.07072003@mail.com

#59 A Fort Santiago St. Bago Bantay Brgy. Alicia Quezon City

+639474683401

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

ST. AUGUSTINE SCHOOL OF NURSING Q.C

TVL - ICT

2019 - 2021

J.P SIOSON GENERAL HOSPITAL AND COLLEGES INC

2014 - 2019

Computer Skills

- Spreadsheet
- Slide presentation
- Front- end
- Graphic Design

John Carlo Jacobe

Software and Hardware Developer

About Me

As an aspiring Full-Stack Developer, I am passionate about creating seamless web applications and solving complex problems with technology. My tech stack spans both front-end and back-end development, with expertise in React.js, Next.js, TypeScript, JavaScript, Node.js/Express.js, PostgreSQL, MySQL, and MongoDB.

I am driven by a deep desire to continually improve my skills, stay at the forefront of industry trends, and leverage my knowledge to build robust, scalable solutions. My ultimate goal is not only to become an expert in full-stack development but also to establish a business related to the IT industry. Coding is my true passion, and I am eager to inspire others on their programming journeys.

Contact

jacobe.johncarlo.02022003@gmail.com

49-P Sampaloc Alley Hills St. Batasan Hills, Quezon City, 1126, Metro Manila, Philippines

+639215820554

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

BATASAN HILLS NATIONAL HIGHSCHOOL

ICT

2019 - 2021

Computer Skills

- Computer Technician
- Full Stack Developer
- Node.js (Express.js) Developer
- React.js & Next.js Developer

Danielle Lunas

Documentation and Hardware Developer

About Me

I want to expand my knowledge and build my own foundation within this field. Good Communication and many more

Contact

lunas.danielle.10262002@gmail.com

103 Ilang Ilang Extension St. Brgy Payatas A. Quezon City

+639563169864

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

BATASAN HILLS NATIONAL HIGH SCHOOL

2015 - 2020

Computer Skills

- Backend Developer

Noahmie Tulod

Documentation

About Me

I am always eager to learn, improve, and expand my technical and graphics skills. I would like to gain new technological skills and methods for managing different types of businesses.

Contact

tulod.noahmie.053101@gmail.com

Salanap Comp, Sitio Mendez Baesa, Quezon City

+6395362816544

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

GARDNER COLLEGE DILIMAN

2019 - 2021

Computer Skills

- IT Support
- Graphic Design

Timothy Joshua Uy

Software and Hardware Developer

About Me

Motivated individual with a strong passion for networking and IT infrastructure. Eager to expand knowledge and develop skills in network administration, security, and cloud technologies. A fast learner with problem-solving abilities and a keen interest in emerging trends within the networking industry. Seeking opportunities to grow professionally and contribute to innovative IT solutions.

Contact

uy.timothyjoshua.12132002@gmail.com

225 Pacamara St. Brgy Commonwealth Quezon City

+63927887688

Language

- English
- Filipino

Education

QUEZON CITY UNIVERSITY

Bachelor of Science in Information Technology

2021 - Present

LAGRO HIGH SCHOOL

2019 - 2021

Computer Skills

- Network Configuration
- Routing and Switching
- TCP / IP Protocol
- Fundamentals of Cybersecurity

APPENDIX L

CERTIFICATION OF THE PROOFREADER

QUEZON CITY UNIVERISTY
673 Quirino Highway, Novaliches, Quezon City

CERTIFICATION FROM THE PROOFREADER

This Capstone Project Entitled

"POWERWALK: Converting Foot Traffic into Sustainable Energy, Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation"

Has been prepared and submitted by

Arella, Vincent G., Bibat, Ian Benjamin, Bustamante, Jefferson, Espeña, Jeremiah B., Esperanzate, Christian, Estonactoc, Kiesha Mel C., Evangelista, Jhun Rey L., Fabia, Aaron Urich C., Fernandez, Lois Meek L., Jacobe, John Carlo P., Lunas, Danielle L., Tulod, Noahmie S., Uy, Timothy Joshua F.

In partial fulfillment of the requirements for the degree of

BACHELOR OF SCIENCE in INFORMATION TECHNOLOGY.

This has been proofread and edited by

MS. MELDRED O. AVILA, MAT, LPT
PRC License No. 0759448

APPENDIX M

CERTIFICATE OF COPYRIGHT APPLICATION

QUEZON CITY UNIVERSITY
RESEARCH, EXTENSION, PLANNING AND LINKAGES
INNOVATION AND TECHNOLOGY SUPPORT OFFICE

CERTIFICATE OF COPYRIGHT APPLICATION

The Office received the Copyright Application of the work with the following details:

Title : POWERWALK: Converting Foot Traffic into Sustainable Energy Utilizing Piezoelectric Transducers with RFID and Data Visualization for Efficient Power Generation

Authors : Arella, Vincent G., Bibat, Ian Benjamin A., Bustamante, Jefferson L., Espeña, Jeremiah B., Esperanzate, Christian G., Estonactoc, Kiesha Mel C., Evangelista, Jhun Rey L., Fabia, Aaron Urich C., Fernandez, Lois Meek L., Jacobe, John Carlo P., Lunas, Danielle L., Tulod, Noahmie S., Uy, Timothy Joshua F.

Maria Aura C. Impang, LPT, MSIT
General Manager, Innovation and Technology Support Office

APPENDIX N

TURN IT IN RESULTS

POWERWALK-FINAL-DOCU-FOR-DEFENSE-REVISE-2.pdf

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File size:	6.92M
Page count:	207
Word count:	23,625
Character count:	136,387
Submission date:	10-May-2025 10:57PM (UTC-0500)
Submission ID:	2668731395

QUEZON CITY UNIVERSITY

"POWERWALK": CONVERTING FOOT TRAFFIC INTO SUSTAINABLE ENERGY, UTILIZING PIEZOELECTRIC TRANSDUCERS WITH RFID AND DATA VISUALIZATION FOR EFFICIENT POWER GENERATION

A Capstone Project Documentation
Presented to
The College of Computer Studies
QUEZON CITY UNIVERSITY

In Partial Fulfillment of the
Requirements for the Degree
BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY

Antilla, Vincent G.
Bihai, Ian Benjamin A.
Bustamante, Jeffrison L.
Espeña, Jeremiah R.
Esperanzate, Christian G.
Balmaquiao, Kiarsha Mel C.
Dongallata, Jhon Rey L.
Fabia, Aaron Uriah C.
Fernandez, Lois Mark L.
Jacalne, Jaike Carlo P.
Lanoy, Daniielle L.
Tulod, Neakimie S.
Uy, Timothy Joshua F.

June 2025

COLLEGE OF COMPUTER STUDIES

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