SOLARIS: A SOLAR-POWERED MOBILE CHARGING KIOSK WITH MOBILE APPLICATION

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ABSTRACT

This project endeavors to develop an autonomous solar energy-based charging kiosk, SOALRIS, in response to the increasing demand for charging stations amid the widespread use of mobile devices. SOALRIS integrates seamlessly with a mobile application enriched with GPS technology, enabling users to conveniently locate available kiosks. Specifically designed to meet the contemporary reliance on mobile devices, particularly smartphones, for charging, SOALRIS features an RFID card-based security system for locking and unlocking phone lockers. The project objectives encompass the prototyping of SOALRIS, the development of the accompanying mobile application, and comprehensive testing of its functionalities. Through a quantitative research study employing a Likert-type questionnaire, feedback from alpha testers, including teachers and students, was gathered, affirming the prototype's success and its commendable input, processing, and output functionalities. The study validates the viability of both the prototype and the mobile application, aligning with project expectations. Notably, the operational effectiveness and security of the SOALRIS system are confirmed, with the security feature proving its efficacy, and the mobile application demonstrating responsiveness to kiosk status. A significant recommendation emerges from the study, advocating for the incorporation of a payment system to enhance the project's self-sufficiency and usability.

Keywords: SOLARIS, Solar-Powered Charging Kiosk, Mobile Application, GPS Integration, Prototype Development, User Feedback, Operational Efficacy, Self-Sufficiency Enchantment, RFID

INTRODUCTION

Nowadays, everyone utilizes a mobile device, especially students. These devices are needed to be charged to be utilized. This is where charging stations shine as there is an increasing demand for it for public use, which drives the market for these stations. Although current products already fulfill this request, innovations can be made for a better and more intuitive experience. A currently available product from the United States of America uses solar power and offers a feature for both wired and wirelessly charging electronics. Unfortunately, not all devices support wireless charging capability therefore the product has a limitation. Another issue is that mobile devices that support wireless charging may experience battery health issues (Tran, 2021).

According to a study conducted in Portugal, manufacturing charging stations is a desirable solution for communities with low incomes and minimal energy usage. Solar-powered stations are being used, particularly in South Asia and Sub-Saharan Africa. However, this brings up several problems with solar charging stations. Since consumers are charged based on the volume of charges rather than the amount of energy used, batteries' durability becomes a problem. This shortens the lifespan of the batteries by allowing them to discharge below the recommended threshold. The management of kiosks is another concern that is brought up since it would be too expensive to hire technical staff to maintain and monitor the stations (Almeida, 2015).

The use of solar-powered cell phone charging stations is the notion of another study conducted in the Philippines. The study's final output came to a few conclusions. The solar panel did not harness the maximum voltage at certain times of the day, which resulted in being manually pointed in the direction of the sun. Another conclusion stated that the allotted charging time of 15 minutes was insufficient for charging cell phones (Maroma, 2014).

There were no local studies found on our chosen topic, a solar-powered charging kiosk. A thorough technical feasibility analysis is necessary as previous studies presented issues on their product. Therefore, we aim to address these by innovating a charging kiosk that is more efficient and better overall. The key features for this project will be the Arduino Mega, Arduino Uno, NodeMCU, and RFID. It is crucial to the system we are building since we plan to develop a mobile app that is in collaboration with the charging kiosks. It will contain essential information such as the location, availability, and condition of the kiosk. This allows the consumers, including students at Mapua Malayan Colleges Mindanao (MMCM), to be familiar with where they can neatly charge at their own choice.

OBJECTIVES OF THE STUDY

This research study aims to achieve the following objectives:

1. To build a prototype solar-powered mobile charging kiosk.
2. To develop the Solaris System Mobile App in correspondence with the availability of the charging kiosks.
3. To test both the kiosk and app in terms of its functionality.

METHODOLOGY

The research methods for this research study are the Developmental-evaluative quantitative research. Developmental research is a method of evaluation that incorporates ongoing evaluation and feedback as a program is created and put into action. This design highlights the significance of incorporating stakeholder feedback and adapting the program as required to increase its efficacy (Patton, 2011).

The Iterative Model was utilized by the developers for this project. It involves refining and revising every implementation of the project. This model has a strong emphasis on adaptation and flexibility, enabling adjustments to be made as needed throughout the project. It consists of the following phases: Initial Planning, Planning, Requirements, Analysis & Design, Implementation, Testing, Evaluation, and Deployment (Sutherland, Schwaber, 2011).

Since our study is quantitative research in nature, we made use of the probability sampling method as our method. To specify, we made use of simple random sampling as a technique for identifying our research respondents. Using an unbiased selection process, simple random sampling ensures that every member of a population has an equal chance of being chosen (Simkus, 2022).

Upon choosing, we utilized an online random number generator by inputting the sample size of thirty developers for alpha testing and fifty end users for beta testing. Respondents are asked to participate and respond to the research survey questionnaire with all honesty. In addition, the inclusion criteria that will be observed before the participant can take part in the research are:

a.) He/She is a bona fide student of the Mapua Malayan Colleges Mindanao institution.

b.) Have voluntarily agreed to be one of the research respondents.

c.) Owns a mobile device that uses either wired or wireless chargers.

The study's design was carried out at Mapua Malayan Colleges Mindanao (MMCM). Since the project was taken place at the campus, permission was needed from the principal of the campus for the study to be conducted. The quantitative approach involved disseminating the survey to gain necessary feedback from our project.

Before Collection. The develoers handed out their consent letters to users who were aware of the purpose of their work. For both alpha and beta testing utilizing IPO, the developers provided a questionnaire. 30 developers and experts were required to complete the questionnaire for the alpha testing. Meanwhile, 50 end users were required for the beta testing.

During the Collection. Microsoft Forms was utilized to collect their responses. The developers were notified after the testers had finished filling out the forms, which were sent to their emails. The developers assisted the testers in filling out the survey questionnaire in order to avoid misunderstandings. Once the testers had finished the questionnaires, the developers processed the information in a confidential manner.

After Collection. The data collection from alpha and beta testing were analyzed after it has been collected by the developers. The beta testing data gave the developers the chance to learn more about the output of their project.

RESULTS AND DISCUSSION

The presentation, analysis, and interpretation of the data acquired for this project are covered in this chapter. The following tables provide the various outcomes along with debates and explanations that go along with them. It also provides solutions to the issues raised in the preceding chapters.

1. Input

The input describes the information being entered into the system, where the statements being questioned are if the kiosk does receive an input. The following questions under this section are: (1) Solar panel generates electricity via sunlight (2) Solar controller manages the distribution of the electrical energy to the battery (3) The locker detects if there is a device currently charged or not (4) The inverter generates 220V AC (5) The GPS module detects the location of the machine (6) Voltage sensor measures the voltage of the battery (7) RFID Scanner detects the locker ID.

Table 1 displays the result for the first indicator, **Input**, where the overall descriptive rating is Very Acceptable. This suggests the system's inputs are fully functional in the users' perceptions. With a mean of 4.56 for the first claim, it is clear that the solar panel could indeed produce power from sunshine. The weather can have a direct impact on the input even though solar panels are a strong option for producing electricity, as noted in an article by Clarke and Sweeney

(2022). With regard to the second claim, it has a mean of 4.44, which shows that the solar controller—where the electric energy is transported from the panel to the controller and then into the battery—is operational. The third statement has a mean of 4.39 as there are indicators for the availability of the lockers.

Table 1
The functionality of the system in terms of its input

Statement	Mean	Descriptive Rating
1. Solar panel generates electricity via sunlight	4.56	Very Acceptable
2. Solar controller manages the distribution of the electrical energy to the battery	4.44	Very Acceptable
3. The locker detects if there is a device currently charged or not	4.39	Very Acceptable
4. The inverter generates 220V AC	4.22	Very Acceptable
5. The GPS module detects the location of the machine	4.22	Very Acceptable
6. Voltage sensor measures the voltage of the battery	4.22	Very Acceptable
7. RFID Scanner detects the locker ID	4.33	Very Acceptable

Additionally, the fourth statement which has a mean of 4.22 shows that the inverter converts the DC power produced by the panel and then goes through the inverter which is generated into AC power. This can be followed with the study by Kondracki (2014), where harvesting solar energy and using the harvested energy requires a converter to AC voltage that can power multiple electronic devices. Following that, the fifth statement has a mean of 4.22 as it shows that the GPS module could locate the device, although sometimes not precisely. The sixth statement also has a mean of 4.22, which shows that the system's voltage sensor does indeed measure the battery's voltage. The seventh statement, which has a mean of 4.33, shows that the RFID scanner was able to pick up the locker ID card.

2. Process

The process describes the information that is being processed into the system, where the statements being questioned are if the kiosk does process well within its system. The following questions of under this section are: (1) The Solar controller will store the harvested electricity in the battery. (2) The green LED indicator turns ON if the locker is available and the red LED indicator turns OFF if unavailable. (3) The inverter produces 220V AC. (4) The GPS module produces the location of the machine. (5) The voltage sensor cuts off the connection of the charger module if a voltage drop occurs. (6) The system will validate the locker ID.

Table 2
The functionality of the system in terms of its process

Statement	Mean	Descriptive Rating
1. Solar controller will store the harvested electricity to the battery.	4.22	Very Acceptable
2. The green LED indicator turns ON if the locker is available and the red LED indicator turns OFF if unavailable.	4.56	Very Acceptable
3. The inverter produces 220V AC.	4.11	Very Acceptable
4. The GPS module produces the location of the machine.	4.06	Very Acceptable
5. The voltage sensor cuts off the connection of the charger module if a voltage drop occurs.	4.11	Very Acceptable
6. The system will validate the locker ID.	4.11	Very Acceptable

Table 2 exhibits the results for the second indicator, **Process**, where all of the questions received a descriptive grade of Very Acceptable. This suggests that users find the system's process to be fully functional. The first statement's mean value is 4.22, indicating that the solar controller is effectively storing the collected electricity in the battery. This is supported by Kondracki's (2014) study, where smaller wire sizes can efficiently transport electricity from the solar panel to the charge controller and batteries. The second statement has a mean of 4.56, indicating that the locker LEDs are functioning as intended. The third statement has a mean of 4.11, indicating that the inverter effectively produces and processes 220 volts, as previously mentioned in Table 1.

Furthermore, the fourth statement has a mean of 4.06, indicating that the system's GPS module performs as planned and displays the product's location as predicted. The fifth statement also has a mean of 4.11, indicating that if a voltage drop occurs, the voltage sensor performs as anticipated. This is supported by the study of Kondracki (2014), where the project needs a system that can monitor voltage levels to avoid overload and damage to the circuit. The sixth claim—which has a mean of 4.11—states that the

RFID system validates the locker ID in accordance with its intended use.

3. Output

The output describes the information that has been processed and is now being outputted from the system, where the statements being questioned are if the kiosk does output its information. The following questions under this section are: (1) Battery powers up all the components of the kiosk. (2) The availability of the locker is reflected on the mobile application. (3) The power outlet charges the phone adapter. (4) 3-in-1 USB cords charge the phones. (5) The location of the machine is displayed in the mobile application. (6) The fast charger module turns off once the battery is low. (7) Battery percentage is monitored and displayed on the mobile application. (8) Locker unlocks if the ID is valid.

Table 3

The functionality of the system in terms of its output

Statement	Mean	Descriptive Rating
1. The battery powers up all the components of the kiosk.	4.50	Very Acceptable
2. The availability of the locker is reflected on the mobile application.	3.94	Acceptable
3. The power outlet charges the phone adapter.	4.39	Very Acceptable
4. 3-in-1 USB cords charge the phones.	4.50	Very Acceptable
5. The location of the machine is displayed in the mobile application.	4.00	Very Acceptable
6. The fast charger module turns off once the battery is low.	4.00	Very Acceptable
7. Battery percentage is monitored and displayed to the mobile application.	4.28	Very Acceptable
8. Locker unlocks if the ID is valid.	4.17	Very Acceptable

Table 3 presents the results for the third indicator, **Output**, where the descriptive rating ranges from Acceptable to Very Acceptable for all items, indicating that the system output is typically functional. With a mean of 4.50 for the first statement, which is considered Very Acceptable, it may be concluded that the battery operates all the components as intended. This is supported by the study of Kondracki (2014), where is supported by the study of Kondracki (2014), where batteries are essential for PV systems, and as such cycles, batteries like lead acid offer efficiency and therefore were used in the project. The second statement, with a mean of 3.94, is Acceptable, indicating some minor problems, but the locker availability that relays to the mobile application is functional. This claim and other succeeding claims regarding mobile applications are supported by the study of Badamasi (2014), as the Arduino platform enables the project to have a versatile application as it can have multiple functions. Moving on to the third statement, which has a mean of 4.39 and is classified as Very Acceptable, it can be seen that the power outlets correctly charge the mobile phones when used with the appropriate phone adapters. Additionally, the fourth statement, with a mean of 4.50 and a Very Acceptable rating, indicates that the 3-in-1 USB cords charge the phones as intended. The location of the machine is displayed in the mobile application, but not properly, according to the fifth statement, which has a mean of 4.00 and is Very Acceptable. The sixth statement, with a mean of 4.00, is Very Acceptable, indicating that the rapid charger module does, in most cases, turn off when the battery level drops. The battery percentage is tracked and accurately shown to the mobile application, as indicated by the seventh statement with a mean of 4.28, which is Very Acceptable. The eighth statement states that the Servo unlocks the locker once the ID is legitimate as intended and has a rating of 4.17.

CONCLUSION

In conclusion, the researchers have successfully developed a prototype solar-powered mobile charging kiosk, utilizing various components such as the ARDUINO MEGA 2560 as a controller, NODEMCU ESP8266 for IoT connectivity, NEO-6M GPS module for location tracking, and ARDUINO UNO for the RFID system. This prototype effectively provides charging services to mobile devices using solar power, demonstrating the feasibility of sustainable energy solutions for charging infrastructure. The data collected from the research indicates that users perceive the availability of the charging kiosk lockers to be satisfactory, with an average rating of 3.87. By integrating locker availability information into the accompanying mobile application, users can conveniently check for vacant lockers before visiting the kiosk, enhancing user experience and efficiency. Furthermore, during the alpha testing phase, the SOLARIS prototype was found to be fully operational and safe for use. The integration of the Blynk IoT application also showcased robust performance and compatibility with the SOLARIS system, highlighting its effectiveness in facilitating remote monitoring and control. Overall, the study underscores the potential of solar-powered charging kiosks in meeting the growing demand for convenient and sustainable charging solutions, while emphasizing the importance of user-centric design and technological reliability in enhancing the adoption and usability of such systems.

RECOMMENDATION

In light of the study's findings, several recommendations are proposed for the enhancement of the solar-powered mobile charging kiosk system:

Firstly, it is recommended to integrate a secure and user-friendly payment system into the kiosk, such as coin slots or online payment methods like cash transfer (GCash). This would not only provide users with a convenient and reliable payment option but also contribute to the self-sufficiency of the product.

Secondly, all lockers should be equipped with RFID technology to improve security and tracking of mobile devices stored within them. Additionally, providing card holders for RFID cards would help prevent loss or damage, ensuring smooth access to the lockers.

Thirdly, considering the installation of larger solar panels for the kiosks is advised to enhance energy absorption and ensure sustainable operation of the system, especially in areas with varying weather conditions.

Fourthly, upgrading to a bigger battery with increased storage capacity is recommended to ensure uninterrupted functionality of the kiosk and extend operating hours, particularly during periods of low sunlight or high demand.

Lastly, implementing a dedicated server using Raspberry Pi with the SOLARIS application is suggested as a cost-effective and reliable option for running the kiosk, particularly in remote areas with limited access to electricity and internet connectivity. These recommendations aim to further optimize the efficiency, reliability, and user experience of the solar-powered mobile charging kiosk system, ultimately contributing to its widespread adoption and success.

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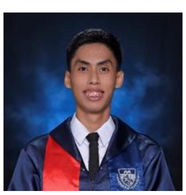
AUTHORS' PROFILE

Simon Justin F. Tomaroy is a senior high school graduate of Mapua Malayan Colleges Mindanao. He graduated with second honors in his 11th and 12th grade year. He finished his elementary and junior high school at Stella Maris Academy of Davao. During his junior year, he received an award of 4th place in Badminton Doubles and 3rd place in Volleyball on Intramurals. During his senior year, his team of developers for SOLARIS received an award of 1st place for having the Best Capstone Research Project. He will be pursuing his Bachelor's degree in Computer Engineering at Ateneo De Davao University.

Rey Paciol, LPT, is a graduate of Bachelor of Science in Secondary Education and is currently an MS Biology student at University of Southeastern Philippines, Obrero, Davao City. He has been a licensed professional teacher since 2013. He is currently a full-time faculty of the SHS Program handling sciences and research subjects, at Mapua Malayan Colleges Mindanao. He was also a former faculty member of the University of Southeastern Philippines under the Natural Sciences Department of the College of Arts and Sciences. His research interests include Natural Sciences, Statistics, Mathematical Modeling and Data Analytics.



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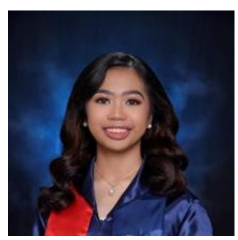
Jojit A. Sitoy is an undergraduate currently pursuing a Bachelor of Science in Computer Engineering at Mapua Malayan Colleges Mindanao. Having graduated from Saint Peter's College of Toril for both elementary and junior high school, Jojit's dedication to learning is evident. Notably, during his senior year, his team's exceptional work on SOLARIS earned them the prestigious 1st place for the Best Innovative Capstone Research Project. With his passion for technology and literature, Jojit aims to contribute meaningfully to the academic community in the future.

Clare Angeli E. Toñacao is a senior high school graduate of Mapua Malayan Colleges Mindanao. She finished elementary school in Proverbs Ville Christian School and finished junior high school in Ateneo de Davao University JHS. She has won various singing competitions in elementary, junior high, and senior high. She will pursue a field in Music after taking a gap year.



Bai Saadiyah A. Sinsuat is a senior high school graduate of Mapua Malayan Colleges Mindanao. She graduated with third honors in her 12th school year. She finished her elementary and junior high school in Albert Einstein School in Cotabato City. She received 1st place in Poster Making during the PSYSC National Youth Science, Technology, and Environment Summer Camp 2019, and participated in many art competitions in Albert Einstein School throughout her school life. She will be pursuing her Bachelor's degree in Architecture at Mapua Malayan Colleges Mindanao.

Kristin Danielle E. Tubang is a senior highschool graduate of Mapua Malayan Colleges Mindanao. She is a woman in STEM and will continue pursuing her studies under the College of Health Sciences, Bachelor of Science in Psychology at the Mapua Malayan Colleges Mindanao. She completed and graduated her junior high in Brokenshire College as a Third Honor and a Rank 12 awardee overall. Kristin always dreamed of being a doctor. With that being said, Kristin aspires to be someone who will help every individual in need and will contribute to society by providing professional healthcare services.

Mark Daniel D. Evangelista is a senior high graduate of Mapúa Malayan College Mindanao. He completed his junior high and elementary at Holy Cross College of Calinan. He is a captivating blend of architecture, music, and athleticism. From crafting spaces to melodies, he is all in. When not sketching building concepts, he composes life's symphony. He is also an avid sports enthusiast, as he thrives on challenges. His achievements include being a Champion of the 2022 Buwan ng Wika Battle of the Bands and of the 2015 Soccer Tournament. He will be staying at Mapúa Malayan Colleges Mindanao for college. Navigating self-discovery through design, melodies, and the pursuit of authenticity.

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