Developing an Arduino-based Car Parking System for Bauan Technical Integrated High School Senior High School Teachers

A Research Proposal
presented to the Faculty
of Senior High School Department of
Bauan Technical Integrated High School

In Partial Fulfillment
Of their Requirements
In Inquiries, Investigations, and Immersions

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APPROVAL SHEET

In partial fulfillment of the requirements for the K to 12 Enhanced Basic Education Curriculum, this research paper entitled, ***"Developing an Arduino-based Car Parking System for Bauan Technical Integrated High School Senior High School Teachers"*** submitted by Emanuel C. Cruzat, Christpher Marc R. Faltado, Suzzane Faye D. Marasigan, and Airash Mith F. Sarsonas is hereby recommended for approval and acceptance for Inquiries, Investigations, and Immersions.

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The Researchers

DEDICATION

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ABSTRACT

The advent of Internet of Things (IoT) technologies has revolutionized connectivity and data processing capabilities, offering unprecedented opportunities for enhancing operational efficiency and productivity. This study explores the feasibility and user experience of an Arduino-based car parking system prototype at Bauan Technical Integrated High School (BTIHS). The research investigates the perceptions and opinions of BTIHS Senior High School teachers regarding the proposed parking solution through a mixed-method approach. Findings from the user-centered design framework reveal nuanced insights into user experience, system functionality, usability, and perception. While users encountered initial challenges, such as navigation difficulties and technical glitches, they expressed positive perceptions of clarity, usability, and potential benefits, suggesting room for improvement. Respondents exhibited strong agreement regarding the system's functionality and favorable opinions towards the proposed parking solution. The study provides valuable insights for refining the system to better meet user needs and expectations, particularly among teachers, while addressing identified challenges to enhance overall user experience.

Keywords: Arduino, Car Parking System, User Experience, Functionality, Usability, Perception, Teachers, Bauan Technical Integrated High School

TABLE OF CONTENTS

INTRODUCTION

The rapid evolution of Internet of Things (IoT) technologies has ushered in an era of unprecedented connectivity and data processing capabilities. Empowered by advancements in communication infrastructure, IoT devices have emerged as powerful tools for gathering, transmitting, and analyzing vast volumes of data. Quy (2022) highlights the potential of IoT and big data solutions in enhancing operational efficiency and productivity. Moreover, Martyna (2023) emphasizes the transformative nature of IoT, envisioning smarter and more responsive systems capable of real-time adaptation to changing conditions. As a conduit for device communication and resource digitization, IoT generates massive datasets that necessitate cloud-based interpretation (Evolution of Internet of Things, 2023).

The escalating number of vehicles within educational institutions like Bauan Technical High School (BTIHS) has presented a pressing challenge in parking space management. This congestion not only disrupts the smooth flow of activities but also incurs frustration and productivity losses among staff and faculty members. Traditional parking management methods, reliant on manual processes or designated zones, often fall short in efficiently addressing the mounting demand for parking spaces within BTIHS. Consequently, challenges such as limited availability, prolonged search times, and faculty dissatisfaction persist. In response to this burgeoning concern, this study endeavors to explore the feasibility of a novel car parking system utilizing Arduino Uno technology.

The landscape of parking management stands to benefit significantly from technological innovations. Smart parking systems, leveraging diverse technologies, have emerged as promising solutions to enhance efficiency and user experience within

parking facilities. Within this context, the research examines the viability of an Arduino-based car parking system as a potential remedy for BTIHS's parking woes. Arduino, renowned for its open-source ethos and user-friendly design, presents an ideal platform for developing cost effective solutions. Through the deployment of an Arduino-based prototype, this study seeks to probe its efficacy in addressing teachers parking challenges at BTIHS.

This research is underpinned by the principle of user-centered design, which advocates for integrating user needs and feedback into technological development processes. Central to this framework is the examination of BTIHS SHS Teacher's user experience with the Arduino-based parking system prototype, focusing on factors such as usability, clarity, and overall satisfaction. The study aims to assess the feasibility of the Arduino-based car parking system prototype's implementation as an independent variable. Dependent variables include user experience, comprising aspects such as ease of use and overall satisfaction, and the feasibility of implementation, encompassing cost estimation and an analysis of practicality within the BTIHS context. By exploring these variables within the user-centered design framework, the research seeks to provide insights into the system's potential effectiveness in addressing teachers parking needs while considering both user experience and feasibility aspects.

This research centers on the development and assessment of user experience pertaining to an Arduino-based car parking system prototype within a controlled environment. The prototype will operate independently of internet connectivity, simulating functionalities for parking availability data collection. Study participants will consist of a limited sample of BTIHS SHS Teachers. The limitations this study

impose is the utilization of a prototype in a simulated environment may fail to fully capture real-world user experiences. Additionally, the limited sample size of BTIHS teachers may restrict the generalizability of findings. Moreover, the focus on user experience precludes a comprehensive exploration of cost-benefit analysis or technical infrastructure requirements for a full-scale system implementation.

The outcomes of this research hold substantial implications for BTIHS. Firstly, the adoption of an Arduino-based system could revolutionize staff parking management, offering a cost-effective and user-centric solution. Secondly, insights garnered from the study may pave the way for a more tailored and user-friendly parking management system, enhancing overall user experience. Lastly, the research lays the groundwork for future endeavors, potentially culminating in the development of a fully functional smart parking system at BTIHS, leveraging Arduino or other technologies.

OBJECTIVES OF THE STUDY

This mixed-method research undertakes a three-pronged approach to explore the potential of a car parking system at BTIHS. Firstly, it aims to develop a functional prototype utilizing Arduino Uno and suitable sensors. This prototype will likely focus on detecting vehicle presence and potentially displaying information like available parking spaces. Secondly, the research will evaluate the perceived value of using the car parking system in schools. This phase will involve gathering qualitative data (surveys, interviews) to assess the prototype's usability, effectiveness in conveying information, and overall user satisfaction. Finally, the research will analyze the feasibility of implementing a full-fledged system within BTIHS. This analysis will

consider the data from user testing alongside the existing infrastructure at the school. By combining these methods, the research aims to not only develop a prototype but also gain valuable insights into user experience and the practicalities of implementing a larger-scale car parking system solution at BTIHS.

HYPOTHESIS

Null Hypothesis (H0): Developing a prototype of a smart parking system for BTIHS teachers will not demonstrate a significant reduction in search time for parking spots or improvement in perceived ease of parking, compared to the current system.

LITERATURE REVIEW

1. Components

A. SERVO MOTOR

Servo motors represent a specialized iteration of small DC motors, incorporating additional components to augment functionality and ease of use. These enhancements include gear reduction mechanisms for heightened torque and decreased speed, a position sensor on the motor shaft for precise control, and an electronic control circuit regulating motor operation. Analogous to an Arduino, servo motors amalgamate fundamental components—a DC motor and a microcontroller—packaged to simplify usage (Servo Motor, 2018).

In the realm of robotics and automation, servo motors emerge as specialized electrical machines adaptable to both direct current (DC) and alternating current (AC) operations. Renowned for their ability to meticulously control mechanical system movement along predetermined trajectories within defined timeframes, servo motors

offer an extensive range of adjustable rotational speeds in both directions, rendering them highly versatile. Consequently, they find application across diverse domains, including medical facilities, robotics, numerically controlled machine tools, and aerospace technology (Servo Motor, 2018).

In contrast, stepper motors, as delineated by Darie et al. (2021), represent a unique category of synchronous machines characterized by distinct design features. Particularly suitable for open-loop precision drive systems, where continuous feedback mechanisms are unnecessary, stepper motors find utility in various applications, including office equipment, robotics, aircraft onboard systems, timing and recording mechanisms, and electronics (Darie et al., 2021).

Unlike conventional motors, servo motors afford precise shaft rotation control, facilitated by a closed-loop system comprising several crucial components. While the motor's core remains standard, it is complemented by a control circuit and a feedback sensor—either an encoder or resolver. This feedback mechanism enables the control circuit to meticulously modulate the motor's power and direction, facilitating the shaft's attainment and retention of specific angles or positions. Additionally, servo motors often integrate a potentiometer, drive gears, and an amplifier to further refine control and efficiency (Realpars, 2023).

B. PASSIVE INFRARED SENSOR

Passive infrared (PIR) sensors play a pivotal role in the development of affordable and effective intrusion detection systems, especially as the demand for smart home security solutions surges in the digital era. Unlike conventional motion sensors, PIR sensors offer distinct advantages in detecting motion, particularly in dark

environments, making them indispensable components for such systems (Pati & Sahoo, 2017).

In recent research, the utilization of PIR sensors in conjunction with other technologies such as ZigBee and ESP8266 modules has been explored to create wireless sensor networks for enhanced security measures. These systems incorporate GSM modules to send text alerts to users when intrusions are detected, providing real-time notifications of potential threats (Pati & Sahoo, 2017).

Furthermore, innovative approaches have been proposed, such as integrating Rochelle salt-based sensors with PIR sensors in Arduino-based intruder detection systems. This hybrid system capitalizes on the piezoelectric properties of Rochelle salt to detect mechanical stress, complementing the infrared detection capabilities of PIR sensors. The redundancy provided by dual sensors ensures continuous monitoring and alarms in the event of intrusions, enhancing overall security (Saini et al., 2016).

Moreover, PIR sensors find application beyond security systems, contributing to energy-saving initiatives in educational environments. By incorporating PIR sensors into classroom lighting and fan control systems, energy consumption can be optimized by activating these utilities only when motion is detected, thus conserving energy when classrooms are unoccupied (Dotche et al., 2017).

Additionally, PIR sensor-based technologies extend to home security systems, where Arduino-based solutions leverage PIR sensors to detect motion and trigger alarms. Integration with smartphone applications allows homeowners to receive real-time alerts and remotely control security systems, providing an accessible and efficient means of safeguarding residential properties (Saringat et al., 2018).

These advancements underscore the versatility and effectiveness of PIR sensors in various applications, ranging from intrusion detection and energy conservation to home automation and security systems.

C. ARDUINO UNO

The Arduino Uno, a prominent microcontroller platform, has garnered widespread popularity due to its user-friendly nature and simplified programming environment. This popularity stems from its utilization of a simplified version of C++, coupled with the ease of programming, erasing, and reprogramming the onboard ATmega328 microcontroller at any given time (Badamasi, 2014).

In examining the Arduino Uno, researchers have delved into its hardware components, software for programming, and practical examples of project construction. This comprehensive analysis provides readers with an understanding of the basic concepts and applications of the Arduino Uno, making it an invaluable resource for both beginners and enthusiasts alike (Badamasi, 2014).

Furthermore, Arduino's open-source nature has facilitated its integration into various educational settings, serving as a tool for electronic prototyping and programming learning initiatives. Galadima (2014) explores Arduino's role in enhancing learning experiences, emphasizing its potential to engage students and enthusiasts in electronics and programming.

Additionally, the versatility of Arduino extends to project development, with Cameron (2019) highlighting its capability to support the construction of complex, simple, and enhanced projects. This underscores Arduino's adaptability to diverse application domains, further solidifying its position as a leading platform for innovation and experimentation.

2. Advantages and limitations of smart parking system

The relentless rise in car ownership needs innovative solutions for managing parking spaces. While intricate smart parking systems exist, Arduino Uno, a popular microcontroller board, offers a cost-effective and accessible alternative for developing basic car parking systems. This literature review explores the advantages and limitations of using Arduino Uno in this context, drawing upon insights from various research endeavors (Chikhale, 2017; Palla, 2022; Malgi, 2022).

This analysis sheds light on the system's potential to enhance user experience by providing real-time information on available parking spaces through LCDs (Chikhale, 2017; Malgi, 2022; Reddy, 2023). This significantly reduces search time and driver frustration (Reddy, 2023). Furthermore, the system automates fundamental management tasks such as vehicle detection using IR sensors (Palla, 2022; Vamshi, 2021) and maintains a record of occupied slots (Chikhale, 2017). Smart Car Parking system is easier, efficient and less time consuming as it helps in tracking the number of cars entered in the parking area which reduces human efforts. The system provides high performance in tracking the car entering and exiting from the parking area and also its presence in a parking slot.

However, it's crucial to acknowledge the inherent limitations of Arduino Uno. Its scalability is restricted, making it suitable only for smaller parking areas (Aziz, 2022). Additionally, the chosen sensors present challenges. IR sensors are susceptible to external interference from factors like sunlight, reducing their accuracy (Palla, 2022). The system requires high maintenance as each sensor must work properly to provide efficiency in working. High power dissipation is recorded through each sensor.

Ultrasonic sensors can be affected by temperature fluctuations, posing another hurdle.

Moreover, Smart Car Parking aims to provide an efficient way of parking for drivers without any hesitation. In conclusion, while Arduino Uno serves as a valuable tool for protecting basic car parking systems, its limitations necessitate exploring more advanced microcontrollers for real-world applications in larger parking spaces. Studies by Chouhan & Sandhya (2017) and Aziz (2022) highlight the importance of incorporating features like mobile app integration and cloud-based data management for improved functionality in practical scenarios.

Similarly, a study by Noor et al., (2022) investigates the factors influencing faculty adoption of Internet of Things (IoT) services in an Iraqi university. The research employs the UTAUT model, including additional factors for privacy and trust, to explore user perceptions through a survey of 302 faculty members. Social influence emerges as the strongest factor influencing the intention to use IoT services, followed by perceived ease of use, privacy concerns, and performance expectations. Facilitating conditions are also found to impact actual usage behavior. The study recommends that decision-makers in higher education promote awareness of IoT benefits and encourage its adoption.

3.1 Existing Implementations (Urban Transformation: Harnessing Technology):

As stated by Swathika (2023), In response to urbanization challenges and sustainability goals, cities are transforming into smart cities. This concept leverages information and communication technologies (ICT) and connected sensors to optimize city operations across various sectors, including public resources, transportation, utilities, and governance. Smart city development relies heavily on Internet of Things

(IoT) applications to enhance service quality, efficiency, and resource management while reducing costs. The global smart city market encompasses advanced infrastructure like intelligent transportation systems, lighting, and other technological advancements. Smart buildings, a key component, integrate various systems to promote occupant well-being, security, resource conservation, and overall environmental health. The implementation of smart cities holds significant promise for improving quality of life, infrastructure, and overall city operations.

Likewise, Sugumaran (2023) explores the concept of smart cities designed with Internet of Things (IoT) technologies to address urban challenges and improve residents' quality of life. IoT creates a network of interconnected devices that collect data, automate tasks, and streamline operations. This technology benefits smart home and building management by reducing operational costs and enhancing resident services. The growing trend towards smart homes, buildings, and cities reflects the increasing demand for well-managed and automated services in urban environments with rising populations.

In addition, a study by Franke (2023) examines how municipalities can manage the public value implications of smart city projects, which utilize new technologies for data collection and automation often developed by private companies. While these technologies address urban challenges, their design can impact public values like privacy. The research explores the risks from privatization and digitization in smart cities and examines how municipalities can collaborate with private actors while safeguarding public values. Through a two-part approach, it analyzes "publicization" frameworks and uses case studies to explore how municipalities govern and collaborate with private companies using various tools. The research concludes that

local governments are well-positioned to ensure public values are protected during technological innovation at the city level.

Also, a study by Kesic (2023) examines the evolving concept of smart cities, moving beyond its initial focus on information and communication technologies (ICT) as a solution to urban problems. While ICT remains important, smart cities are now understood as requiring a holistic approach that prioritizes human and social capital. The paper aims to provide a systematic analysis of this evolution, exploring how the conceptualization of smart cities, its key dimensions and indicators, and its relationship to similar concepts have changed over time.

In a study by Gregory et al., (2023) explores the concept of smart cities, emphasizing their use of technology and data to improve quality of life, infrastructure efficiency, and sustainability across various sectors. Through a structured literature review, the research examines smart city definitions, advantages, disadvantages, implementation challenges, funding sources, applications, analysis techniques, and prioritization metrics. The study further analyzes international smart city implementation and proposes strategies to overcome challenges. The authors propose a definition for smart cities: "employing digital and communication technologies with data analytics to create an efficient service environment that enhances urban life quality and promotes sustainability." The paper concludes that smart cities offer a promising path for urban development, with technology and data integration potentially revolutionizing how cities function in the face of growing complexity.

3.2 Implementation in Institution:

Research in India explores the growing adoption of Internet of Things (IoT) technologies in supply chain management (SCM) as a response to rising global uncertainties and the demand for efficiency and affordability. The study focuses on the application of IoT in the food grocery and manufacturing industries, both of which faced significant challenges during the COVID-19 pandemic and are critical for social and economic development. The findings suggest that IoT offers significant benefits for these industries, including enhanced food safety and security in emergencies, improved supply network efficiency through integration with e-commerce platforms, reduced costs and minimized waste in goods transportation for manufacturing, and increased supply chain reliability through real-time tracking and improved equipment maintenance. However, the research also acknowledges the potential security vulnerabilities associated with data breaches in IoT systems, highlighting the need for stronger security measures as a key area for future improvement in SCM applications (Haposan et al., 2024)

Parallel to other studies, a study conducted by Kathiravan (2023) proposes an IoT-based electronic parking system (e-parking system) for shopping malls and multiplexes. The system uses ultrasonic sensors to detect parked vehicles and Wi-Fi modules to transmit data wirelessly to a cloud server. This data is then displayed on a central display at the entrance, guiding drivers to available parking spaces. Additionally, they emphasize the system's affordability, scalability, and potential for job creation in the local youth community through installation and maintenance. Finally, the paper acknowledges the possibility of further customization and modularity for broader application across various buildings.

Moreover, a study by Amanda et al., (2019) addresses the increasing demand for parking at the Polytechnic of Leiria, a university in Portugal. To tackle this challenge, the authors propose a smart parking system that utilizes sensors and a mobile application to help users locate available parking spots. This integrated system aims to improve campus parking efficiency by providing real-time information to users.

In addition, Gheorghiu (2021) describes a smart parking system simulation designed for educational purposes using Ladder Diagram programming. The system serves as a platform for students to learn the principles of process automation in Programmable Logic Controllers (PLCs). It teaches students about program elements, PLC implementation, logic diagram creation, and program simulation. The authors highlight the system's relevance in adapting educational methods for remote learning environments and emphasize the growing importance of virtual labs and e-learning platforms in higher education due to the increasing digitalization trend.

Additionally, Gosavi et al., (2023) proposes a "Smart Parking System" as an intelligent solution to parking challenges faced by businesses and urban areas with growing numbers of vehicles. The system aims to optimize parking management and potentially reduce energy consumption and pollution. While precisely tracking real-time parking availability across locations remains a challenge, the system can still aid parking attendants in locating empty spaces. The authors suggest that implementing this smart parking system can contribute to economic growth, though the specific mechanism isn't elaborated upon.

Furthermore, a study by Nagajayanthi (2021) emphasizes the increasing adoption of IoT by businesses and consumers due to its potential for increased

productivity and convenience. It discusses how cloud vendors leverage AI for data analysis in IoT systems, while digital assistants provide voice user interfaces. However, the paper acknowledges security vulnerabilities in centralized architectures and proposes Blockchain technology for data security and transparency. Additionally, it mentions Robotic Process Automation (RPA) and facial recognition as potential tools for various applications. The paper concludes by emphasizing the transformative potential of IoT, including its ability to create adaptable, responsive, and costeffective systems. Finally, it mentions the implementation of a smart classroom as an example of IoT applications.

Lastly, Bhaskaran (2023) examines how the Internet of Things (IoT) can revolutionize higher education. It acknowledges the growing importance of IoT and its potential benefits, but also recognizes the need to address associated risks. The paper explores how universities can leverage IoT to enhance undergraduate education across various disciplines. It emphasizes the significant potential for educational institutions but highlights the importance of ensuring long-term and effective implementation by faculty, staff, and students. The paper positions universities as potential leaders in advancing and improving IoT technologies. It also references research exploring the future of IoT in higher education. Finally, the paper acknowledges the challenges that IoT presents for higher education.

Local Literature

Efficient parking management has become increasingly critical in the Philippines, particularly with the surge in vehicle numbers leading to wasted travel time for drivers searching for parking spots. Addressing this challenge, Adlawan et al. (2013) developed a user-friendly Commercial Car Park Operation System. Employing

Sensory Motors with a Computer Interface and Intelligent Search Algorithm, the system streamlines parking processes by detecting vehicle entry and exit, issuing printed stubs, and facilitating payment calculation. This innovation significantly reduces the time spent by customers in search of parking spaces, particularly in commercial areas. Similarly, Gungon et al. (2015) conducted a case study focused on enhancing the parking system at Target Mall in Santa Rosa, Laguna. Their implementation of an ultrasonic sensor-based system with LED indicators, counters, and displays greatly alleviated the inconvenience faced by drivers and mall patrons. Furthermore, Demegillo et al. (2016) introduced a Real-Time Viewing Automated Parking System, leveraging proximity sensors and a mobile-accessible web application. This system empowers drivers to reserve parking slots remotely, reducing parking congestion and enhancing convenience. These innovative solutions not only offer practical approaches to parking management but also prioritize the comfort and efficiency of individuals navigating urban spaces in the Philippines.

Synthesis

The development of a smart parking system relies on integrating various components such as servo motors, passive infrared (PIR) sensors, and Arduino Uno microcontroller boards (Servo Motor, 2018; Pati & Sahoo, 2017; Badamasi, 2014). Servo motors offer precise control over mechanical system movement, making them ideal for tasks such as gate control and vehicle barrier management in parking systems (Servo Motor, 2018). PIR sensors serve as key components for detecting vehicle presence and motion, contributing to intrusion detection and energy-saving initiatives (Pati & Sahoo, 2017). Arduino Uno serves as the central control unit, facilitating communication between components and enabling real-time parking

management (Badamasi, 2014). Despite Arduino Uno's scalability limitations, its affordability and accessibility make it suitable for basic smart parking systems (Aziz, 2022). However, limitations exist, such as restricted scalability and challenges with sensor accuracy due to external factors (Aziz, 2022; Palla, 2022).

Local literature provides practical examples of sensor-based parking solutions addressing urban congestion and enhancing mobility (Adlawan et al., 2013; Demegillo et al., 2016). Adlawan et al. (2013) and Demegillo et al. (2016) present actual examples of sensor-based parking systems that manage urban congestion and improve mobility in the Philippines. These local initiatives highlight the importance of integrating sensor technologies to address urban parking challenges effectively. Overall, the synthesis emphasizes the significance of sensor-based solutions in improving parking management efficiency and urban mobility.

METHODS

Respondents of the Study

As seen on Table 1 the respondents of this study comprise twenty (20) Senior High School teachers at Bauan Technical Integrated High School (BTIHS) who own a car. Due to the manageable size of the target group, this study opted to recruit the entire population of Senior High School teachers at Bauan Technical Integrated High School (BTIHS) who own a car (n = 20). This approach ensures a comprehensive analysis of user experience within this specific group, eliminating sampling errors and providing a complete picture of how teachers with vehicles perceive the system. While larger sample sizes are generally preferred for research, the unique situation here allows for indepth data collection from the entire relevant population (Andrade, 2020).

BTIHS		
Teachers	Population	Owns a Car
SHS Teachers	77	20

Table 1

Population Table

Research Design

This research utilizes a descriptive design with a mixed methods approach. This involves describing the user experience of Senior High School teachers at Bauan Technical Integrated High School (BTIHS) as they interact with the developed prototype for a car parking system built on the Arduino platform. Descriptive research provides a detailed and accurate picture of the characteristics and behaviors of a particular population or subject (Sirisilla, 2023).

Qualitative research is an investigative method focused on gaining nuanced insights into real-world phenomena (Moser et al., 2017). Quantitative research entails gathering and scrutinizing numerical data. Its applications include identifying patterns and averages, predicting outcomes, examining causal connections, and extrapolating findings to broader populations (Bhandari, 2023). The research will employ mixed methods research blends aspects of both quantitative and qualitative methodologies to address research inquiries comprehensively. This approach offers a more holistic understanding compared to solely quantitative or qualitative investigations, as it incorporates the advantages of both methodologies (George, 2023).

Data Gathering Instrument

To comprehensively evaluate user experience with the Arduino-based car parking system prototype, the research will employ a two-pronged approach utilizing distinct data gathering instruments.

The first approach involves qualitative data collection through user testing sessions. During these sessions, participants will interact with the prototype while researchers employ various methods to gain in-depth insights. The think-aloud protocol, where participants verbalize their thoughts, allows researchers to understand user thought processes while interacting with the system. Finally, researchers will observe user behavior and interaction with the prototype, taking detailed notes.

The second approach focuses on quantitative data collection through a user feedback survey. This survey will utilize closed-ended questions, in the form of Likert scales, to assess user experience aspects like functionality, usability of the prototype, and perception and opinions. This approach allows for broader data collection and identification of trends in user perceptions of the prototype.

Statistical Treatment of Data

This research utilizes a mixed methods approach, requiring separate analysis strategies for qualitative and quantitative data, followed by their integration to gain a comprehensive understanding.

For the qualitative data, researchers will employ thematic analysis on observation notes captured during the controlled user testing session. Thematic analysis involves systematically identifying, analyzing, and reporting recurring themes within the data. This process begins with researchers familiarizing themselves with the notes to gain a holistic understanding of user interactions with the prototype. Next, researchers will code segments of text that represent significant aspects of user experience, such as ease of use, encountered challenges, and suggestions for improvement. These codes will then be grouped into broader themes that capture the most prominent patterns across the data. Finally, the identified themes will be refined, defined, and presented with supporting quotes or observations to effectively illustrate user experiences with the prototype.

In contrast, the quantitative data gathered from the user feedback survey, which utilizes closed-ended questions, will be analyzed using descriptive statistics. Descriptive statistics summarize the data using measures of central tendency (e.g., mean) to understand users' average perceptions on functionality, usability of the prototype, and perception and opinions. Additionally, measures of variability (e.g., standard deviation) will be employed to assess how widespread the responses are for each question. Data visualization techniques such as tables and graphs will be used to effectively communicate these findings.

The final step involves integrating the qualitative and quantitative results. Researchers will explore how the identified themes from user observations, such as confusing interface elements, support or provide context to the quantitative data on user experience ratings, such as lower ease of use scores. This triangulation of data

strengthens the research by providing a more holistic and nuanced understanding of user experience with the Arduino-based car parking system prototype.

Data Gathering Procedure

This research employs a two-phased approach to gather data on user experience with the Arduino-based car parking system prototype, focusing on Senior High School teachers at Bauan Technical Integrated High School (BTIHS) who own vehicles:

Phase 1: User Testing Session and Feedback

1. **Participant Recruitment:** Based on the pre-survey results, researchers will identify and recruit Senior High School teachers who own a car. An invitation to participate in a user testing session will be issued, assuming logistical feasibility is confirmed.
2. **Informed Consent:** Prior to the session, participants will receive a detailed informed consent form. This document will explain the research objectives, data collection methods used, and participants' rights regarding confidentiality and voluntary participation.
3. **Prototype Demonstration:** Researchers will conduct a brief demonstration of the Arduino-based car parking system prototype. This demonstration will clearly explain the functionalities of the system and how users can interact with it.
4. **Individualized User Interaction:** Each participant will be assigned a dedicated time slot for individual interaction with the prototype within a controlled environment. Researchers will observe user behavior during this time, focusing

on factors such as ease of use, navigation patterns, and any challenges encountered.

5. **Observation Notes:** Throughout the user testing session, researchers will take comprehensive observation notes. These notes will document user behavior, encountered challenges, verbal comments, and any other relevant observations related to user experience with the prototype.
6. **Think-Aloud Protocol:** Participants may be encouraged to verbalize their thoughts and thought processes while interacting with the prototype.

Phase 2: User Feedback Survey

1. **Survey Distribution:** Subsequent to the user testing session, participants will be provided with a user feedback survey to complete.
2. **Survey Design:** The survey will utilize a combination of closed-ended questions (Likert scale).

Data Storage:

All collected data, including pre-survey responses, observation notes, and survey responses, will be stored securely and confidentially in accordance with established ethical research protocols.

RESULTS AND FINDINGS

This section presents the results and discussion that the researchers have gathered through the process of conducting investigation of the study on developing an Arduino-based Car Parking System for Bauan Technical Integrated High School

Senior High School Teachers. It is divided into four (4) parts: 1) User Experience, 2) Functionality, 3) Usability, and 4) Perception and Opinions.

User Experience

Table 2 shows the thematic analysis delves into user experiences with an Arduino-based car parking system prototype, drawing upon data collected from observation sheets of 20 participants. The analysis explores how users interacted with the system, the challenges they encountered, and their overall impressions. The analysis revealed four (4) key themes that illuminate user experiences with the prototype.

Themes	Description	Observation
Usability **Hurdles**	This theme encompasses the difficulties participants faced while navigating the system, interacting with its features, and completing assigned tasks. Codes such as: ● ***navigation issues*** ● ***usability issues*** ● ***incomplete task completion***	A portion of participants (2 participants) wrestled with navigating the system, encountering roadblocks that hindered their progress. Technical problems, particularly with sensors (reported by 9 participants), emerged as a significant barrier for some users, preventing them from completing tasks as intended. Additionally, 11 participants encountered usability issues with specific functionalities, suggesting areas for refinement in the system's design
Learning Curve and System Exploration	This theme captures the initial learning curve associated with using the prototype and participants' approaches to exploring its capabilities. Codes such as: ● ***partial task completion*** ● ***exploration*** ● ***confusion***	Not all participants grasped the system's intricacies immediately. While some users (6 participants) completed tasks successfully and swiftly (within 0-5 seconds), others required more time (up to 5 minutes), suggesting a learning curve. However, 6 participants exhibited exploration patterns, actively trying to understand the

		system's potential by navigating various features. Interestingly, 3 participants displayed moments of confusion while interacting with the prototype, highlighting areas where the system's intuitiveness could be improved.
Encouraging User Perceptions	This theme highlights positive user sentiment regarding specific aspects of the prototype. Codes such as: • ***Clarity*** • ***Usability*** • ***Benefits*** • ***Confidence*** • ***Engagement*** • ***relief/excitement***	A significant portion of participants (17) expressed positive affirmations about the system's clarity and ease of use. This suggests that the prototype successfully conveyed information in a way that users found understandable and straightforward. Furthermore, several participants (17) commented on the potential benefits the system could offer, particularly in terms of saving time searching for parking spaces. Notably, non-verbal cues like confidence, engagement, relief, and excitement displayed by a large number of participants (17) provide additional evidence of generally positive user perceptions.
Technical Issues Demanding Attention	This theme focuses on technical problems encountered by users, pinpointing areas that require further development. The code ***"technical problems"*** (particularly related to sensors) is central to this theme.	Sensor-related technical problems were the most frequently encountered technical difficulty (reported by 9 participants). This highlights a critical area for further development and troubleshooting to ensure the system functions reliably.

Table 2

User Experience: Thematic Analysis Table

Functionality

Table 3 shows the results of Likert scale surveys assessing the functionality of the car parking system. The data reveals that across all five statements, respondents strongly agreed with the system's functionality. Statement 5 received the highest mean score of 3.85, indicating a particularly strong agreement, while Statements 1, 2, 3, and 4 also garnered high mean scores ranging from 3.65 to 3.8. The consistency in the median and mode values, all being 4, further emphasizes the unanimous agreement among participants. Additionally, the low standard deviations across all statements suggest minimal variability in responses, reinforcing the robustness of the findings. Overall, these results affirm the positive perception of the car parking system's functionality among respondents.

Statement	***N***	***Mean***	***Median***	***Mode***	***Standard Deviation***	***Verbal Interpretation***
Statement 1	20	3.65	4.00	4	0.49	Strongly Agree
Statement 2	20	3.7	4.00	4	0.57	Strongly Agree
Statement 3	20	3.8	4.00	4	0.52	Strongly Agree
Statement 4	20	3.65	4.00	4	0.49	Strongly Agree
Statement 5	20	3.85	4.00	4	0.37	Strongly Agree

VA: Strongly Agree: 4.00-3.00, Agree: 2.99-2.00. Disagree: 1.99-1.00, Strongly Disagree: 1.00-0.99

Table 3

Functionality: Results from the survey questionnaire using a 4-point Likert scale

This aligns with existing literature highlighting the importance of efficient parking systems focusing on functionality among participants and overall urban mobility. Studies such as Sugumaran (2023) and Kathiravan (2023) have highlighted the positive impact of well-designed parking systems on reducing congestion, enhancing accessibility, and improving overall urban mobility. The high levels of agreement observed in this study affirm these findings, suggesting that a well-functioning parking system contributes to a positive user experience and sustainable transportation practices. However, it's crucial to acknowledge that not all studies may report such unanimous positivity. Research like Servon and Nelson (2003) might present contrasting views, suggesting that certain factors such as cost, location, and design elements could influence users' perceptions differently. These studies emphasize the importance of considering contextual factors and user preferences when evaluating the effectiveness of parking systems. Therefore, while this study reflects a positive consensus, it's essential to recognize the potential variability in user experiences and perceptions across different contexts, which could contribute to divergent findings in the literature.

Usability

Table 4 shows the results of Likert scale surveys assessing the usability of the car parking system. The data indicates a generally positive perception among participants, with all statements receiving mean scores above 3. Statement 2 achieved the highest mean score of 3.75, followed closely by Statement 4 with the same score. Statements 1, 3, and 6 also garnered mean scores above 3.5, indicating strong agreement regarding usability. However, Statement 5 received a comparatively lower mean score of 3.2, suggesting slightly less agreement with its usability. Despite this

variability, the median and mode values for all statements were consistently 4 indicating a prevalent agreement among respondents, except Statement 5 scoring 3. The standard deviations ranged from 0.44 to 0.77, suggesting moderate variability in responses across statements. Overall, the data suggests a generally positive perception of the usability of the car parking system, with some variations in agreement across specific aspects.

Statement	***N***	***Mean***	***Median***	***Mode***	***Standard Deviation***	***Verbal Interpretation***
Statement 1	20	3.55	4.00	4	0.60	Strongly Agree
Statement 2	20	3.75	4.00	4	0.44	Strongly Agree
Statement 3	20	3.5	4.00	4	0.61	Strongly Agree
Statement 4	20	3.75	4.00	4	0.44	Strongly Agree
Statement 5	20	3.2	3.00	3	0.77	Strongly Agree
Statement 6	20	3.6	4.00	4	0.60	Strongly Agree

VA: Strongly Agree: 4.00-3.00, Agree: 2.99-2.00. Disagree: 1.99-1.00, Strongly Disagree: 1.00-0.99

Table 4

Usability: Results from the survey questionnaire using a 4-point Likert scale

The study by Nagajayanthi (2021) aligns with the results of Table 4, which indicate a positive perception of the usability of the car parking system. Nagajayanthi (2021) discusses the transformative potential of IoT (Internet of Things) technology, emphasizing its ability to enhance productivity and convenience. This aligns with the concept of a smart parking system, which utilizes IoT sensors and mobile applications to improve parking efficiency by providing real-time information to users, as proposed by Amanda et al. (2019). Both studies recognize the benefits of technology-driven solutions in addressing parking challenges and improving user experience. However,

Nagajayanthi (2021) also acknowledges security vulnerabilities in centralized IoT architectures, which could be a concern for users interacting with parking systems. To address this, Nagajayanthi proposes Blockchain technology for enhanced data security and transparency, which could potentially alleviate any security-related concerns and further improve the usability and acceptance of smart parking systems. Therefore, while both studies emphasize the potential benefits of IoT-based parking solutions, Nagajayanthi's insights on security considerations and proposed solutions offer valuable perspectives for enhancing the usability and acceptance of such systems.

Perception and Opinions

Table 5 illustrates the perceptions and opinions of teachers regarding the car parking system, as assessed through Likert scale surveys. The data indicates a strong agreement among teachers across all three statements. Statement 2 received the highest mean score of 3.8, closely followed by Statements 1 and 3 with mean scores of 3.7 and 3.65, respectively. The consistency in median and mode values, all at 4, underscores a unanimous agreement among participants. Additionally, the low standard deviations ranging from 0.41 to 0.49 suggest minimal variability in responses, reinforcing the robustness of the findings. Overall, these results highlight a positive perception and favorable opinions among teachers regarding the system.

Statement	***N***	***Mean***	***Median***	***Mode***	***Standard Deviation***	***Verbal Interpretation***
Statement 1	20	3.7	4.00	4	0.47	Strongly Agree
Statement 2	20	3.8	4.00	4	0.41	Strongly Agree
Statement 3	20	3.65	4.00	4	0.49	Strongly Agree

VA: Strongly Agree: 4.00-3.00, Agree: 2.99-2.00. Disagree: 1.99-1.00, Strongly Disagree: 1.00-0.99

Table 5

Perception and Opinions: Results from the survey questionnaire using a 4-point Likert scale

The findings from Table 5, which indicate a strong agreement among teachers regarding the car parking system, align well with the concept of smart cities as explored by Sugumaran (2023). The integration of Internet of Things (IoT) technologies in urban infrastructure, such as the car parking system, reflects a broader trend towards leveraging technology to enhance urban services and residents' quality of life. Studies supporting this perspective, such as Kesic (2023) and Gregory et al., (2023), emphasize the positive impact of smart city initiatives on improving urban efficiency and convenience. These studies suggest that technologies like IoT can optimize parking management systems, making them more user-friendly and efficient, which could explain the favorable perceptions among teachers in this study. However, it's important to acknowledge potential contradictions in the literature. Research such as Nagajayanthi (2021) might present differing perspectives, suggesting that despite the benefits of IoT integration, concerns about data privacy, security vulnerabilities, and digital divide issues could impact public perceptions and acceptance of smart city technologies. These conflicting viewpoints underscore the complexity of urban technology adoption and the need for comprehensive approaches that address both benefits and challenges. Therefore, while this study aligns with the positive outlook on smart city technologies, it's essential to consider potential barriers and concerns raised in the literature to ensure effective implementation and acceptance among users like teachers.

CONCLUSION

Based on the findings, the following conclusions were drawn:

1. **Interpretation of results in User Experience:** The thematic analysis paints a nuanced picture of user experience with the car parking system prototype. While users encountered challenges, particularly with navigation, technical issues (sensors), and an initial learning curve, the analysis also reveals positive user perceptions regarding clarity, usability, and potential benefits. By addressing the identified shortcomings, the system's usability can be significantly improved.
2. **Interpretation of results in Functionality:** Across all five statements, respondents displayed strong agreement with the system's functionality. Statement 5 received the highest mean score of 3.85, indicating significant concurrence, while Statements 1, 2, 3, and 4 also attained high mean scores ranging from 3.65 to 3.8. The uniformity in median and mode values, all at 4, underscores unanimous agreement among participants. Additionally, low standard deviations across all statements indicate minimal response variability, bolstering the study's robustness. Overall, the findings affirm a positive perception of the car parking system's functionality among respondents.
3. **Interpretation of results in Usability:** Participants generally perceived the car parking system positively, with all statements receiving mean scores above 3. Statement 2 scored the highest at 3.75, closely followed by Statement 4. Statements 1, 3, and 6 also had mean scores above 3.5, indicating strong agreement on usability. However, Statement 5 received a lower mean score of 3.2, suggesting slightly less agreement. Despite this, median and mode values

for all statements were consistently 4, indicating prevalent agreement, except for Statement 5. Standard deviations ranged from 0.44 to 0.77, indicating moderate variability in responses. Overall, the data suggests a generally positive perception of the car parking system's usability, with some variations in agreement across specific aspects.

4. **Interpretation of results in Perception and Opinions:** The data reveals a strong consensus among teachers across all three statements regarding the car parking system. Statement 2 obtained the highest mean score of 3.8, closely followed by Statements 1 and 3 with mean scores of 3.7 and 3.65 respectively. Consistent median and mode values of 4 indicate unanimous agreement. Low standard deviations ranging from 0.41 to 0.49 suggest minimal variability in responses, strengthening the findings' reliability. Overall, the results reflect positive perceptions and favorable opinions among teachers regarding the car parking system.

Overall, the comprehensive analysis of user experience, functionality, usability, and perception among teachers regarding the car parking system prototype reveals a nuanced picture. While users encountered initial challenges such as navigation difficulties and technical glitches, they also expressed positive perceptions of clarity, usability, and potential benefits, suggesting room for improvement. Respondents displayed strong agreement regarding the system's functionality, with high mean scores and minimal variability in responses, underscoring its reliability. Despite some variability, participants generally perceived the system positively, indicating a generally positive perception of usability, with scope for enhancement in specific areas. Teachers exhibited a strong consensus, with high mean scores and minimal variability, reflecting positive perceptions and favorable opinions towards the system.

Overall, these findings provide valuable insights for refining the system to better meet user needs and expectations, particularly among teachers, while addressing identified challenges to enhance overall user experience.

RECOMMENDATIONS

Based on the results, the following recommendations are hereby presented:

1. **Monitoring screen:** This system would not only count the number of available cars but also provide real-time identification of specific parking slots. By displaying the availability of individual slots, users can easily locate and navigate to vacant spaces, thereby reducing congestion and improving overall parking efficiency.
2. **RFID-Based Parking System:** This system can utilize RFID cards issued to users at the school gates, enabling the identification of vehicle types (e.g., motorcycles, cars, bikes) upon entry. By categorizing vehicles, the parking management can optimize space allocation and provide tailored services based on the specific needs of different vehicle types, contributing to a more organized and efficient parking environment.
3. **Solar back up car parking system:** Given the positive perception of the car parking system among participants, integrating solar technology can enhance sustainability efforts while also reducing energy costs associated with traditional parking infrastructure. By harnessing solar energy, the benefactor can reduce reliance on conventional grid-based electricity, thereby lowering operational costs and minimizing environmental impact.
4. **For future researchers:** Building upon the present study, future research could delve deeper into the specific factors influencing users' perceptions and

preferences regarding parking systems. This could involve investigating the impact of additional features or amenities, assessing the effectiveness of different technological integrations, or exploring the influence of pricing models on user satisfaction. Additionally, longitudinal studies tracking user perceptions over time could provide valuable insights into the long-term effectiveness and sustainability of parking system implementations. By addressing these aspects, future research can further contribute to enhancing parking system design and management practices.

APPENDIX A

Observation Sheet (For Researcher)

Study: ***Developing an Arduino-based Car Parking System for Bauan Technical Integrated High School Senior High School Teachers***

Participant:_____

Date: _____

Session: 1

System/Prototype: Car Parking System

Observer: Cruzat, Faltado, Marasigan, Sarsonas

Pre-Session Notes:

Briefly describe the participant's background or relevant information

years of driving experience: _____

familiarity with similar technology: _____

Observations:

General Demeanor:

Describe the participant's overall mood and level of engagement throughout the session.

- ☐ confident
- ☐ hesitant
- ☐ curious

Task Completion:

Record the participant's progress in completing assigned tasks with the prototype.

- ☐ successful completion
- ☐ encountered difficulties
- ☐ time taken

Note any specific actions taken or strategies used by the participant.

_____
_____
_____
_____

System Interaction:

Describe how the participant interacts with the different features of the prototype.

- ☐ focus on specific functionalities
- ☐ exploration patterns

Are there any difficulties encountered

- ☐ navigation issues
- ☐ technical problems
- ☐ others: _____

Verbal Cues:

Note any additional verbal comments or expressions not explicitly stated during think-aloud.

- ☐ sighs of frustration
- ☐ positive affirmations

Non-Verbal Cues:

Record any non-verbal behavior that might indicate user experience.

- ☐ confusion
- ☐ ease of use

Include specific gestures, facial expressions, or body language cues.

_____
_____
_____

Survey Questionnaire

Study: ***Developing an Arduino-based Car Parking System for Bauan Technical Integrated High School Senior High School Teachers***

Participant:_____

Date: _____

Session: 2

System/Prototype: Car Parking System

Researcher: Cruzat, Faltado, Marasigan, Sarsonas

To what extent do you agree with the following statements about the functionality of the car parking system prototype?	SD	D	A	SA
The features of the car parking system prototype met my expectations for finding parking information.				
The information displayed (e.g., available parking spaces, location indicators) was accurate and helpful.				
The system provided enough detail about available parking options to make informed decisions.				
I found the functionalities of the prototype to be relevant for addressing parking challenges at BTIHS.				
The system offered features that I believe would be beneficial for daily parking management at school.				

To what extent do you agree with the following statements about the usability of the car parking system prototype?	SD	D	A	SA
I found the car parking system prototype to be easy to use. The layout of the system was clear and intuitive.				
I felt comfortable navigating through the different functionalities of the system.				
The system responded promptly to my actions (e.g., button presses).				
I was able to quickly understand the information displayed on the prototype.				
If I encountered any difficulties, the system provided clear instructions or error messages.				
Overall, I found the interaction with the prototype to be user-friendly.				

Perceptions and Opinions	SD	D	A	SA
This type of car parking system could significantly improve parking management at BTIHS.				
The implementation of this system would be a positive change for the school community.				
The car parking system prototype seems like a feasible solution for addressing parking concerns at BTIHS.				

CURRICULUM VITAE

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PERSONAL BACKGROUND

Birthday:	May 27, 2006
Birthplace:	Dr. Bejasa General Hospital Bauan, Batangas
Nationality:	Filipino
Religion:	Roman Catholic
Height:	164 cm
Weight:	42 kg
Civil Status:	Single
Father's Name:	Arcadio R. Cruzat
Mother's Name:	Liza C. Cruzat

EDUCATIONAL BACKGROUND

Senior High	Bauan Technical Integrated High School Bauan, Batangas 2024
Junior High	Bauan Technical Integrated High School Bauan, Batangas 2022
Primary	Alagao-Malindig Elementary School 2018

Name: Christopher Marc R. Faltado
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PERSONAL BACKGROUND

Birthday:	December 27, 2005
Birthplace:	Bauan General Hospital Bauan, Batangas
Nationality:	Filipino
Religion:	Roman Catholic
Height:	170 cm
Weight:	95 kg
Civil Status:	Single
Father's Name:	Marceliano C. Faltado
Mother's Name:	Rhodora R. Faltado

EDUCATIONAL BACKGROUND

Senior High	Bauan Technical Integrated High School Bauan, Batangas 2024
Junior High	Bauan Technical Integrated High School Bauan, Batangas 2022
Primary	Bauan East Central School Bauan, Batangas 2018

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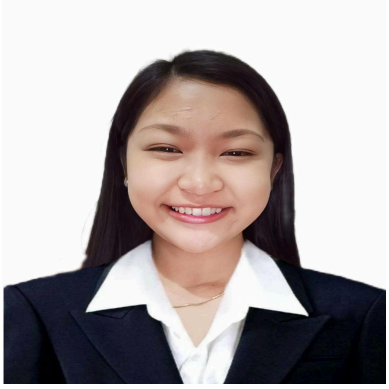

PERSONAL BACKGROUND

Birthday:	December 19, 2005
Birthplace:	Aplaya, Bauan, Batangas
Nationality:	Filipino
Religion:	Roman Catholic
Height:	160 cm
Weight:	56 kg
Civil Status:	Single
Father's Name:	Efren B. Marasigan
Mother's Name:	Evilita D. Marasigan

EDUCATIONAL BACKGROUND

Senior High	Bauan Technical Integrated High School Bauan, Batangas 2024
Junior High	Bauan Technical Integrated High School Bauan, Batangas 2022
Primary	West Bauan Central School Bauan, Batangas 2018

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PERSONAL BACKGROUND

Birthday:	December 7, 2005
Birthplace:	St. Patrick's Hospital
Nationality:	Filipino
Religion:	Jehovah's Witnesses
Height:	154 cm
Weight:	50 kg
Civil Status:	Single
Father's Name:	Smithel L. Sarsonas
Mother's Name:	Sarah F. Sarsonas

EDUCATIONAL BACKGROUND

Senior High	Bauan Technical Integrated High School Bauan, Batangas 2024
Junior High	Bauan Technical Integrated High School Bauan, Batangas 2022
Primary	Our Lady of Lourdes School of Bauan Inc. Bauan, Batangas 2018

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AND THIS IS OUR RESEARCH!

HOOORAAAY ROAD TRIP BROOM BROOM

DRIFT DRIFT!!!!!!