Chapter 1

THE PROBLEM AND ITS SETTING

Introduction

In the vast fields of every industry, document printing has been in demand as it is a necessity for students and professionals alike as well as for the public. With document printing becoming a global trend, it comes with the demand for printing shops rising as not all people can afford printers or are at least not interested in getting one. While printing shops are spreading across the country, especially near schools and workplaces, it becomes a competition when it comes to prices.

A problem that a lot of people have been experiencing, not only in the printing industry but in every consumer-related situation, is the inconsistent pricing structures. In a business, pricing is crucial as it affects how consumers interact with their product or their service. Pricing inconsistency can have such factors as regional pricing, dynamic pricing, and personalized pricing (FasterCapital, 2024). Consumers may decide to find another service that offers more consistent and fairer pricing if other competitors are available in the area. However, the situation is not always like that.

Recent criticisms towards a local printing shop in Puerto Princesa, Palawan have caught the attention of Palawan News. Netizens have raised concerns about the unfair pricing of the said printing shop in which it does not have standard pricing in black and white and colored prints (Badilla, 2024). Although the printing shop owner defended the claim of having unfair pricing, she clarified that their rates have always been the same.

According to Article 81 of the Republic Act No. 7394 or the Consumer Act of the Philippines (DTI, 2022), the pricing of goods and services, such as document printing services, must be regulated to protect consumers from unfair prices. Also, the prices of each service must be disclosed to consumers for transparency. Although the printing shops post the prices of their printing services, it is not clear what the print covers, especially on colored prints. Sometimes, the price on colored prints changes according to its size and its price changes depending on the estimation of the service provider.

To support this information, the researchers made an online survey through Google Forms, with questions that are focused on the inconsistent pricing of print shops near PUP-CEA. Some questions are “Have you been affected by the high and random prices of printing services?”, “Have you ever been dissatisfied with the transparency of pricing in the printing shops?”, and “Have you ever been charged a higher price for colored printing even when the documents had only a small colored logo or image?” with “Yes” or “No” answers as the respondents’ choices. Most of their answers resulted in “Yes” which means they feel the inconsistency of the pricing of the printing shops when it comes to colored printing.

Aside from document printing pricing being inconsistent, there is a need for people to have access to more convenient and efficient ways of printing solutions. One solution that is expected to have a significant impact on the world of printing is to have a self-service printing kiosk (Data Analytics Visionaries, 2024)

Introducing InstaPrint: A Printing Kiosk with Standardized Pricing and Efficient Services Operated Through Coin and GCash Payments. This printing solution helps address the need for a more convenient and efficient way of printing while having a user-friendly interface designed to make the device easier. InstaPrint aims to ensure to have a fair and standardized pricing and its affordability to students while having flexible payment options with coins and cashless payments through GCash. Within this study, a discussion is to be made to have a brief understanding of the technical, operational, and innovative benefits of InstaPrint – highlighting the potential to revolutionize the printing services within PUP-CEA.

Theoretical Framework

Technological Integration

InstaPrint integrates a variety of technologies, including Arduino UNO, Python, HTML, CSS, and Visual Basic, ensuring smooth operation and robust security measures for user data (Aguanta et al., 2024). The Arduino UNO microcontroller board controls essential components such as the coin slot, printer, and coin hopper, facilitating seamless functionality and user interaction (Taşdemir, 2023). Arduino's user-friendly interface and extensive community support make it an ideal platform for rapid prototyping, particularly beneficial for beginners entering embedded systems development.

User Satisfaction and Acceptance

Technology Acceptance Model (TAM) assesses user perceptions of ease of use, usefulness, and behavioral intentions (Barlaan et al., 2024). TAM provides insights into user satisfaction and interaction with self-service kiosks like InstaPrint.

Payment Flexibility and Operations

InstaPrint accepts both coins and GCash, leveraging the increasing popularity of digital payments in the Philippines (Espeleta, 2022). This dual-payment approach enhances convenience and security for users while reducing the operational risks and costs associated with handling physical cash (Enojas et al., 2023). By embracing digital transactions, InstaPrint aligns with modern payment preferences, ensuring a seamless user experience and operational efficiency.

Document Transfer and Accessibility

Users can upload documents via Flash drive or wirelessly through a dedicated application, enhancing accessibility and usability (Aguanta et al., 2024). This feature supports various document formats like PDFs and PowerPoints, simplifying the printing process.

Fair Pricing and Market Integration

InstaPrint aligns with digital printing standards by implementing fair and transparent pricing strategies based on document complexity and size (AdrTechIndia, 2024). This ensures equitable service delivery across educational, library, and commercial settings.

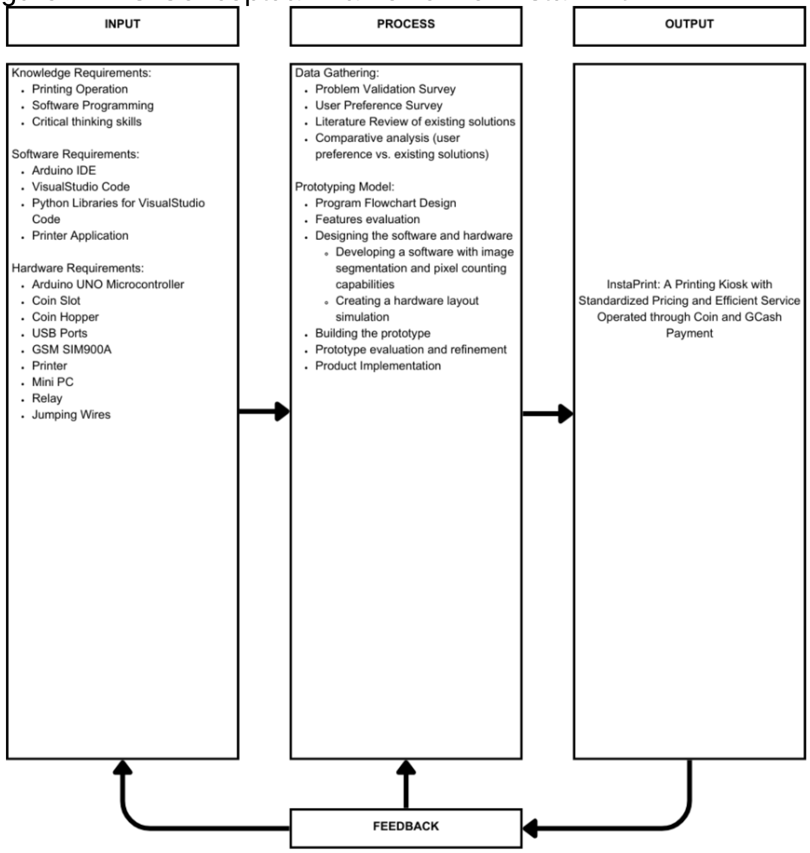
Image Processing

InstaPrint leverages advanced image segmentation algorithms for precise document processing, enhancing pricing accuracy and service efficiency (Hu et al., 2019).

Conceptual Framework

The concept of this research is to create a printing solution with standard pricing. Therefore, this framework focuses on the process of printing and price standardization. The researchers adopted the Input-Process-Output model, which provides a clear and organized flow of details regarding the printing process.

Figure 1. IPO Conceptual Framework of InstaPrint



The INPUT includes knowledge of printing operations, software programming, and critical thinking skills. Other components are hardware such as an Arduino UNO microcontroller, a coin slot, a printer, and software such as the Arduino integrated development environment, Visual Studio code, and Python libraries.

The PROCESS of developing InstaPrint starts with data gathering through problem validation, a survey, and a literature review. It then moves on to the prototyping phase, including program flowchart design, feature evaluation, software and hardware development prototype construction, and evaluation before implementation.

The OUTPUT of the process would be the InstaPrint. A working printing kiosk offers standardized pricing, efficient service, and multiple payment methods for users. It is used to print documents in a variety of file types and accept payments with GCash and other currencies.

The FEEDBACK loop included in the project refers to the ongoing collection of feedback and data analysis to determine other areas that could be improved and developed in the InstaPrint kiosk. This mechanism guarantees continuous improvements to cater to user needs and improve overall user satisfaction.

Statement of the Problem

The objective of this study is to develop InstaPrint - an efficient and fair printing kiosk meant for solving the printing cost and accessibility issues near the College of Engineering and Architecture (CEA) at the Polytechnic University of the Philippines (PUP) in Sta. Mesa, Manila. Specifically, the researchers aim to address the following inquiries:

1. What are the main problems faced by students and faculty members of PUP CEA when using printing services?
    1.1 Service cost basis;
    1.2 File sharing method;
    1.3 Payment method.
2. What specific limitations or shortcomings exist in the current printing services offered near PUP CEA?
    2.1 Inconsistent and high service costs;
    2.2 Limited payment options;
3. How does InstaPrint address the identified research gaps in printing services?
    3.1 Standardized and fair pricing model;
    3.2 Multiple payment options (coins and GCash);
    3.3 Enhanced accessibility and user experience.
4. What are the developmental stages of InstaPrint?
    4.1 Feature identification;
    4.2 Product design;
    4.3 Prototyping;
    4.4 Implementation.
5. How does InstaPrint enhance the overall user satisfaction of PUP CEA students and faculty members?
    5.1 Ease of use;
    5.2 Reliability of services;
    5.3 Quality of printed materials.

6. What impact does InstaPrint have on the time efficiency of printing services for PUP CEA users?

   6.1 Reduction in waiting time;

   6.2 Speed of transaction completion;

   6.3 Availability of kiosks.

Hypothesis

There is a significant difference in customer satisfaction between traditional printing services and self-service InstaPrint printing kiosks. Customers using InstaPrint kiosks report higher satisfaction levels due to greater convenience, speed of service, and potentially lower costs compared to traditional printing services. InstaPrint has features that offer a more convenient and efficient way of printing documents. It also has a feature where an algorithm is used to standardize the price for each document. These features of the InstaPrint printing kiosk will result in higher satisfaction than traditional printing services.

Scope and Limitations of the Study

InstaPrint, the proposed printing kiosk at the College of Engineering and Architecture (CEA) of the Polytechnic University of the Philippines (PUP) in Sta. Mesa, Manila, aims to provide a fair and standardized pricing model for document printing based on the color content in each file. This system will support document uploads in PDF, DOCX, JPG and PNG. By utilizing image segmentation, the kiosk will determine the printing cost based on the color content on the files, providing utmost fairness in pricing for all users.

InstaPrint operates both on cash and online payment, accepting one-peso, five-peso, ten-peso, and twenty-peso coins as well as GCash balance using QR codes. One-peso coins will be used as change when using coin-based payment. The kiosk will only accept Philippine pesos to ensure compatibility with the local currency. Users will transfer files through online upload via QR scan, ensuring a fast and seamless upload process. Based on the results of our survey, document printing will be limited to short bond paper only. This decision reflects the actual usage patterns and preferences of the majority of respondents, who indicated that short bond paper is the most commonly used and practical format for their printing needs. Supporting only one paper size simplifies maintenance, reduces paper supply costs, and minimizes user confusion when operating the printers. It also ensures efficient use of resources and aligns the service with the real demands of the users, rather than offering options that are rarely utilized.

The kiosk is planned to be placed on the 3rd floor of the CEA building, accessible to students, faculty, and other members of the PUP community. However, only one user can access the kiosk at a time to ensure privacy and reduce waiting times. Moreover, the system includes a feature that monitors ink levels and limits the number of pages allowed per transaction to avoid disruptions when ink levels are low. This ensures smooth operation and prevents incomplete print jobs, maintaining user satisfaction and conserving resources.

To protect user data, InstaPrint will incorporate an auto-delete function that ensures files are automatically erased after the printing process, enhancing data security through self-destructing files. While InstaPrint offers a streamlined and fair pricing model, it does have some limitations. InstaPrint offers a standard printing quality only, which may not cater to users requiring specialized or high-end printing options. The system will only accept Philippine pesos for cash payments and does not support other currencies. Furthermore, InstaPrint cannot accept bills, limiting cash payments to coins only. Users who use physical currency to avail themselves of the service depend on the availability of change on InstaPrint's stack of one-peso coins.

Significance of the Study

This study makes some important contributions to the development of printing with standardized pricing and efficient services operated through coin and GCash payment.

Students. Most requirements of the students of PUP-CEA require them to print out these requirements. In line with this, the students face challenges with the subjective pricing of the files printed in printing shops which becomes unsystematic. InstaPrint solves this problem through standard pricing and offers a dual payment system catering to their preferences.

Faculty. This study benefits the faculty staff that also requires printing their materials for their daily needs. The availability and easy accessibility of the kiosk printer not only aids them to their needs but also makes it easier for them to access without the need to seek out traditional print shops.

Future Researchers. This research is open for other future researchers who aim to improve and broaden the scope and limitations of the study. This study can serve as their initial data which can be beneficial for the further development of their study which can focus on the improvement of InstaPrint's functions and services.

Definition of Terms

Arduino Microcontroller. A programmable device used to send signals to relays, activating the corresponding hopper based on the value of the detected coin. It ensures efficient and controlled dispensing of change to users.

Coin Hopper. A component used for coin processing and temporary storage of coins.

Coin Slot. An opening in a printing kiosk designed for the insertion of coins.

Embedded System. A specialized combination of computer hardware and software created to perform a specific function.

GCash. A globally recognized micropayment service turning a smartphone into an electronic wallet or e-wallet for safe, quick, and easy money transfers.

Image Segmentation. A process of dividing a digital image into multiple segments or regions to simplify or change its representation for easier analysis.

Microchip ATmega328P. A low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture, commonly used in embedded systems.

Microcontroller. A compact integrated circuit designed to control a specific operation within an embedded system.

Pixel. The smallest unit of a digital image, often represented as a tiny dot or square.

Pricing Inconsistency. Variations in pricing for the same product or service due to factors such as material costs, service charges, or other variables.

Printing Kiosk. A machine that allows users to print various types of documents.

QR Scan. A method of reading a Quick Response (QR) code, a type of barcode, by using a digital device. QR codes store data as a grid of square-shaped pixels.

Relay. An electrically operated switch that transfers signals to other devices, enabling remote or automated control in various applications.

Standardized. Adhering to a set standard to ensure consistency and regularity in operations or outputs.

Chapter 2

REVIEW OF LITERATURE AND STUDIES

Introduction

In today's information-driven society, printing services play a vital role in supporting a wide range of tasks for both academic and professional purposes. The emergence of innovative solutions, particularly self-service kiosks, has transformed user expectations; however, limited research explores the effectiveness of these automated systems within densely populated academic environments, where cost management, reliability, and user autonomy are critical factors.

This research addresses this gap by proposing a campus-specific kiosk design that integrates image-based color analysis for transparent pricing and a standalone QR code upload interface, promoting both affordability and convenience.

Although campus printing kiosks have the potential to meet students' demands for cost-effective, reliable, and efficient printing services, existing systems often lack dynamic pricing mechanisms and seamless mobile integration. The proposed solution implements real-time image segmentation to calculate per-page costs instantly and employs a QR code-based upload and payment system, reducing dependence on on-site staff, minimizing wait times, and improving operational flexibility.

A thorough review of relevant literature forms the basis of this study, yet existing reviews typically fail to connect technological advancements directly to practical kiosk implementations in educational settings. By aligning key findings related to touchscreen interfaces, pricing strategies, and payment systems with the proposed kiosk prototype, this research bridges theoretical insights and practical applications, informing both the development of research questions and methodological approaches.

An extensive analysis of academic and industry sources on the evolution of printing kiosks, standardized pricing methods, payment integration, and self-service efficiency highlights current trends and identifies gaps in price transparency and accessibility within educational environments. This review also outlines key areas for future research, particularly in the development of adaptive pricing algorithms and user-centered design practices.

Printing Kiosks

Several studies describe the evolution of printing from manual services to automated kiosks, highlighting features like touchscreens and wireless connectivity. However, this research largely focuses on listing features rather than evaluating their performance in real-world campus environments. To address this, our study will measure actual kiosk uptime and queue lengths during peak student hours to assess whether these innovations genuinely improve service speed and efficiency.

While touchscreen interfaces are known to simplify menu navigation (Dionisio et al., 2024), academic studies rarely report concrete usability metrics such as task completion time and error rates. To close this gap, we will conduct controlled trials to record how quickly and accurately students complete typical printing tasks using touchscreens, providing measurable evidence of usability.

Mobile-device printing is now common, allowing users to send files directly from smartphones and tablets. Yet, there is little data on the reliability of these connections or the frequency of failed transfers. Our project will log successful and failed mobile uploads over a semester to pinpoint connection stability issues and guide system improvements.

Advanced kiosks support options like color printing, duplex mode, and various paper sizes, offering more user flexibility. However, no studies have examined whether self-service kiosks accurately calculate printing costs across these options. We will integrate real-time image segmentation into the billing engine to ensure that pricing reflects actual ink and paper usage, promoting fair and transparent charges.

Finally, while market reports mention major providers such as GWI, Beijing OSK, and Shanghai Zhuxin (HackMD, 2024), none analyze how commercial kiosks handle regulatory pricing compliance or adapt to campus-specific payment methods. Our project directly addresses this by embedding local pricing regulations into a QR-based upload and payment system that supports both coin payments and mobile wallets, delivering a fully compliant and campus-friendly solution.

Standardized Pricing using Image Segmentation Techniques

Image segmentation divides a digital image into multiple segments to simplify analysis and is widely used to estimate colored ink usage in printing. While prior studies have demonstrated that segmentation can help calculate printing costs by analyzing the proportion of colored pixels on a page, this work typically focuses on algorithm performance rather than practical integration into real-time billing systems. Our project addresses this by embedding image segmentation directly into the kiosk's billing engine, ensuring that page prices accurately reflect actual ink usage at the point of transaction.

Hu et al. (2019) proposed an improved image segmentation algorithm combining graph cut theory with the artificial bee colony algorithm for multi-threshold segmentation. Their method introduced a new weight function that accounts for both gray level and pixel location, along with a novel cost function suitable for square and non-square images. By minimizing this cost function, the algorithm effectively identifies optimal image thresholds. Experimental results on public datasets showed superior performance in Information Entropy (IE), Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), Root Mean Squared Error (RMSE), and processing time compared to other algorithms.

However, despite these technical advances, existing studies stop at algorithm evaluation and do not explore deployment in real-world printing environments. Our project closes this gap by implementing and testing the algorithm within a functioning kiosk system, validating not just accuracy but also its impact on billing fairness and user satisfaction in a live educational setting.

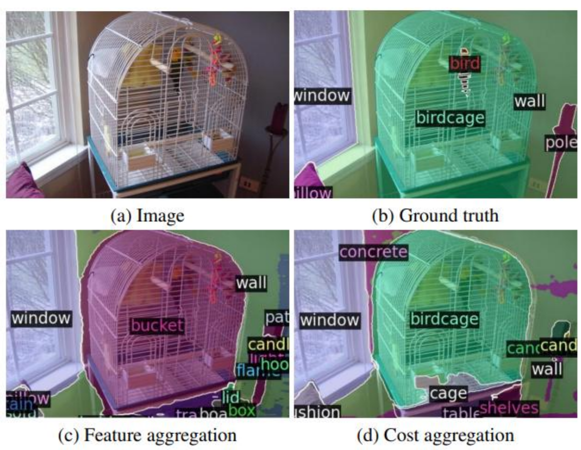
Figure 2. Tree-level segmentation results of different algorithms: (a) origin image, (b) segmented image using Hu et al.'s method, (c) segmented image using BA algorithms, (d) segmented image using MMSA algorithms, (e) segmented image using IBA algorithms, and (f) segmented image using OTSU algorithms.

The algorithm introduced in this paper outperforms other image segmentation methods by achieving higher Information Entropy (IE), Peak Signal-to-Noise Ratio (PSNR), and Structural Similarity Index (SSIM), while reducing Root Mean Squared Error (RMSE) and processing time. However, despite these improvements, such studies primarily concentrate on algorithmic performance metrics and do not explore their application in real-time printing cost calculations. Our project bridges this gap by implementing these advanced algorithms within a live kiosk system to assess their effectiveness in accurately and efficiently calculating print costs based on ink usage.

Similarly, Cho et al. (2023) proposed an approach to optimize image-text similarity maps using cost aggregation, enhancing open-vocabulary semantic segmentation. Their method adapts vision-language foundation models, particularly CLIP, to label pixels based on diverse text descriptions. By aggregating cosine similarity scores between image and text embeddings, they fine-tuned CLIP's encoders to effectively segment both seen and unseen classes. While this study demonstrates strong segmentation performance, it focuses on semantic understanding rather than practical deployment for operational systems like self-service kiosks.

Our work moves beyond theoretical advancements by integrating these segmentation techniques directly into a real-world kiosk billing system, validating not just algorithmic accuracy but also their operational viability in calculating fair, usage-based printing costs under real-world constraints.

Figure 3. Qualitative comparison between feature and cost aggregation. Cho et al.'s approach (d) successfully segments the previously unseen class, such as "birdcage," whereas approach (c) fails.



The proposed CAT-Seg framework fine-tunes CLIP's encoders to adapt them for segmentation tasks. The method not only surpasses previous state-of-the-art performance in standard benchmarks, but also excels in scenarios with considerable domain differences. The demonstrated success across diverse domains underscores the potential of this cost aggregation framework to significantly advance open-vocabulary semantic segmentation.

Pricing

Article 81 of the Consumer Act of the Philippines mandates fair pricing and transparency in service provision. While compliance is critical to avoid legal consequences and maintain consumer trust, many print shops still operate without standardized pricing models. InstaPrint directly addresses this gap by implementing a transparent, standardized pricing system that fully complies with regulatory requirements—providing a clear advantage in a market where consumers increasingly demand fairness and accountability.

The case study “Print Shop Owner Clarifies Pricing Discrepancy Amid Online Criticism” by Badilla (2024) highlights the real-world impact of inconsistent pricing. A print shop in Puerto Princesa faced significant public backlash due to perceived pricing discrepancies, despite the owner’s claims of consistency. This incident underscores the business risks of opaque pricing practices and the urgent need for transparent, verifiable pricing protocols, which InstaPrint systematically implements to avoid such reputational damage.

FasterCapital (2024) explores how inconsistent and complex pricing strategies—such as regional disparities, dynamic algorithms, and personalized pricing—create perceptions of unfairness, driving consumers toward businesses with straightforward pricing models. This reinforces the importance of transparent and easily understandable pricing, a principle that guides InstaPrint’s pricing approach to build lasting consumer trust.

Additionally, the Department of Trade and Industry (DTI) mandates that businesses clearly display price tags to prevent deceptive practices and ensure transaction transparency. Non-compliance carries penalties, underscoring the critical role of regulatory frameworks in protecting consumers. InstaPrint fully integrates these compliance measures into its QR-based payment and pricing system, ensuring legal adherence while simplifying cost calculations for consumers.

Together, these studies and regulatory guidelines highlight persistent issues with pricing transparency in the printing industry. InstaPrint resolves these challenges by offering precise, standardized pricing tied directly to actual service usage, reducing ambiguity, enhancing customer satisfaction, and positioning itself as a trusted, regulation-compliant service provider in a competitive market.

Payment Systems for Kiosks

A comprehensive review of payment systems for kiosks reveals a clear shift from traditional coin-operated models to digital payment methods. While many studies and case reports discuss the technical implementation of these systems, they often lack insights into user preferences, payment reliability, and real-world adoption challenges. This project addresses this by integrating both coin and mobile payment options, including GCash, and evaluating their effectiveness through actual usage data collected in a campus environment.

Parameswari et al. (2019) explored an automated, self-service machine for public browsing and printing using Raspberry Pi, featuring a pay-and-use model. While this system introduced automation and a basic payment interface, it did not assess payment method flexibility or user acceptance in diverse socio-economic contexts.

InstaPrint fills this gap by offering multiple payment channels and tracking their usage patterns to optimize user experience and accessibility.

Diaz et al. (2022) analyzed socio-economic factors affecting mobile money adoption in General Santos City, finding that GCash dominated with a 96% adoption rate. Key satisfaction drivers included convenience, trust, and system availability, while reliability issues negatively affected satisfaction. Despite these insights, their study stops short of examining how these factors play out in service environments like printing kiosks. InstaPrint directly responds to these findings by prioritizing system reliability and offering GCash integration to meet established user preferences, while also monitoring transaction success rates to identify and address potential reliability issues.

As Espeleta (2022) noted, digital payments in the Philippines have surged due to their convenience and security. However, many self-service platforms still fail to fully capitalize on this trend, limiting user choice or neglecting system transparency. Our project goes further by combining digital payment options with standardized pricing models to ensure fair, transparent transactions, while also reducing operational risks and costs associated with cash handling (Enojas et al., 2023).

In summary, although prior studies explore payment technologies and user behavior separately, few connect these insights to practical, real-world deployment in self-service kiosks. InstaPrint addresses this critical gap by delivering a fully integrated, user-centric payment solution that combines regulatory compliance, operational efficiency, and the digital payment preferences of Filipino consumers.

Efficiency in Self-Service Kiosks

Existing literature on the operational efficiency of self-service kiosks emphasizes their potential to minimize downtime, streamline processes, and enhance user experience through intuitive design and advanced technologies like AI and IoT. While these studies outline general efficiency benefits, they often lack empirical data from actual deployment scenarios in specific contexts, such as campus environments. Our project addresses this by monitoring kiosk uptime, usage patterns, and user feedback directly within a live academic setting to evaluate real-world operational efficiency.

Self-service kiosks are widely recognized for automating repetitive tasks like order processing and payment collection, reducing staff workload and accelerating service delivery (Concepts, 2024). Additionally, their ability to operate 24/7 expands service availability and improves customer convenience compared to traditional counters (Shannon, 2023). However, most research focuses on these theoretical advantages without quantifying actual performance metrics like service uptime, maintenance frequency, and queue reduction in practical deployments. InstaPrint closes this gap by tracking and analyzing these metrics over an extended period, providing concrete data on operational effectiveness.

Studies also highlight that intuitive, user-friendly designs are critical for customer adoption and satisfaction, emphasizing clear instructions and easy issue resolution. Yet, many kiosk implementations fail to incorporate direct user feedback into iterative design improvements. InstaPrint overcomes this by collecting detailed user experience data and using it to refine kiosk interface design and functionality, ensuring higher adoption and satisfaction rates.

Despite their benefits, self-service kiosks involve significant upfront costs and operational risks, including potential user errors and technical failures (Concepts, 2024). While this is well-documented, there is limited research on how to mitigate these risks effectively in practice. InstaPrint tackles this issue by implementing preventive maintenance schedules, monitoring failure points, and designing for ease of troubleshooting, reducing downtime and improving reliability.

In summary, while the literature recognizes the potential of self-service kiosks to improve efficiency and customer satisfaction, it often lacks real-world validation and actionable strategies for overcoming deployment challenges. InstaPrint directly addresses these gaps by combining empirical performance monitoring with continuous design and operational optimizations, ensuring both efficiency gains and a positive user experience in a real-world academic environment.

Case Studies and Related Projects

Several case studies of printing kiosk projects were analyzed to identify best practices and common implementation challenges. While these studies demonstrate the potential of automated kiosks to improve accessibility and efficiency, they also reveal recurring technical and operational limitations that hinder long-term effectiveness. InstaPrint addresses these gaps by integrating modern technologies and payment systems, coupled with a strong focus on system reliability, security, and user experience.

Baisa et al. (2023) developed a coin-operated printer for schools, offices, and public spaces, but encountered significant challenges including coin recognition errors, printer connectivity issues, software bugs, security vulnerabilities, and maintenance difficulties. Their study underscores the importance of regular maintenance and robust hardware/software design, lessons that InstaPrint applies by utilizing digital payments to reduce reliance on mechanical coin mechanisms and implementing remote monitoring for proactive maintenance.

Parameswari et al. (2019) introduced a 24/7 automated browsing and printing system using IoT technology. While their solution improved accessibility, it primarily focused on coin-operated payments and lacked integration with more flexible digital payment methods. InstaPrint builds on this by offering QR-based mobile payments, ensuring greater convenience and compatibility with modern user habits.

Arcibal et al. (2019) designed a self-operated vending machine using a touchscreen LCD and internet-connected printers, but their system could not provide monetary change and focused solely on basic print services. InstaPrint overcomes these limitations by incorporating dynamic pricing linked to actual ink and paper usage, ensuring transparent and accurate billing, and eliminating the need for physical change through digital payments.

Dionisio et al. (2024) developed a document printing kiosk specifically for engineering students at Aurora State College of Technology. While effective in reducing queues and improving access, their solution relied on coin payments and a limited set of software tools. InstaPrint advances this approach by combining multiple payment options, including widely used platforms like GCash, and integrating modern software architectures to support enhanced reliability, usability, and real-time analytics.

These case studies demonstrate the potential of printing kiosks to enhance service delivery but also highlight critical shortcomings in payment flexibility, security, system reliability, and maintenance. InstaPrint systematically addresses these challenges by leveraging IoT technologies, offering modern digital payment systems, implementing real-time monitoring, and ensuring compliance with regulatory standards to deliver a scalable, secure, and user-friendly printing solution.

Synthesis of Reviewed Related Literature and Studies

The reviewed literature and studies collectively emphasize the growing need for efficient, transparent, and accessible printing services, particularly in academic environments where high demand and limited resources often lead to service inefficiencies. Traditional printing services have faced criticism for inconsistent pricing, limited payment methods, and poor operational efficiency, which negatively impact user satisfaction.

The development of self-service kiosks emerged as a viable solution to these challenges. Studies show that self-service kiosks significantly improve service delivery by automating repetitive tasks, reducing queues, and minimizing operational costs. However, despite these benefits, existing kiosk systems often suffer from limitations such as inadequate payment flexibility, lack of integration with advanced technologies, and failure to comply with local pricing regulations.

Advanced technological integrations such as image segmentation algorithms have been recognized for improving cost transparency by accurately determining ink usage based on document content. Yet, most prior studies have focused only on algorithmic efficiency rather than real-world implementation. InstaPrint addresses this gap by applying these advanced algorithms directly into its billing system, ensuring fair pricing based on actual usage while complying with the Consumer Act of the Philippines.

Moreover, the review highlighted the importance of flexible and reliable payment systems. While digital payment platforms like GCash have become widely popular in the Philippines, many kiosks have not yet fully adopted such systems. InstaPrint overcomes this by integrating both coin-operated and digital payment methods, offering greater convenience and accessibility to users with diverse preferences.

Operational efficiency, another critical theme in the literature, has often been discussed theoretically but rarely validated in real-world academic environments. InstaPrint distinguishes itself by conducting live performance evaluations within a university setting, using real-time monitoring of user feedback, system uptime, and service speed to ensure continual improvements.

Case studies further reinforce these findings, revealing that while earlier projects made strides in automating printing services, they frequently fell short in key areas such as pricing fairness, system reliability, and maintenance. InstaPrint learns from these shortcomings by incorporating preventive maintenance schedules, remote system monitoring, and user-centered design enhancements, ensuring high levels of reliability and user satisfaction.

In conclusion, the synthesis of literature and studies underscores the necessity of combining advanced technological solutions, fair and transparent pricing, flexible payment systems, and operational efficiency to create a modern, user-friendly printing kiosk. InstaPrint embodies these principles, offering a practical and scalable solution tailored to the needs of academic institutions.

Chapter 3

METHODOLOGY

This chapter presents the research design, description of the research instruments used, statistical treatment to be used, as well as the process flow chart and the design project flow.

Research Design

This study aims to have standardized pricing of document printing. While achieving this, the study also offers a more convenient and efficient way of printing that would reduce wait times.

In the main problem, which involves the inconsistent pricing of nearby printing shops in PUP-CEA, the researchers had created an online survey that would be answered by the students to verify the need of an alternative printing service inside the campus.

The target participants in this survey are the students inside PUP-CEA. In this survey, the questions asked were based on their experiences in availing the printing services near PUP-CEA and along with their preferences.

The researchers designed a prototype that includes the hardware and software components of the printing kiosk. With the hardware, the researchers used the application SketchUp to create the design of the printing kiosk. For the software, the researchers developed the user interface of the website along with the source code that would identify the file to be printed and calculate its price based on its pixel count.

After all, another survey will be conducted along with usability tests to gather feedback from users of the developed prototype. The collected feedback will help verify the convenience and efficiency that this study was expected to deliver and to determine user satisfaction.

The researchers created a formula to calculate the pricing standards for prints in both grayscale and color. The cost of printing is determined based on several factors, including the type of paper, the complexity of the document (whether grayscale or color), and the total number of printed pixels. Since only short bond paper is supported based on survey results, the paper cost is calculated specifically for that size. The maximum cap for the final price per page is also predefined to avoid excessive pricing. For a **grayscale print**, the price is determined by evaluating the document's content. If the document is predominantly white and contains little text, the price will be calculated at a lower base rate. In contrast, if the document has more complex features, such as edges or varied pixel intensity, the price increases. Key factors such as **edge density** (which measures the amount of detail in the image) and **entropy** (which measures the randomness or complexity of pixel patterns) are used to determine the base price. This base price is then adjusted based on the paper cost and capped at the predefined maximum price to ensure fair pricing.

For **color printing**, the process begins by assessing the color coverage within the image. This is done by converting the image into an HSV color space and calculating the percentage of pixels that contain color. If there is little to no color coverage, the price remains low, while higher color coverage results in a higher base price. The color price is then adjusted by multiplying by 1.5 to reflect the additional cost of colored ink compared to grayscale printing. Like grayscale printing, the final price is also capped at a predefined maximum to prevent overly expensive prints.

1. Grayscale Printing Formula

The pricing for grayscale printing is determined by considering both the paper cost and the complexity of the document. The paper cost is dependent on the paper size, while the complexity is measured by factors such as edge density and entropy of the image. These factors directly influence the base price for the grayscale print.

Let:

- **C_paper** = Paper Cost per Page (₱3.00 for short size)
- **Base_price** = Computed Based on Document Complexity (₱2.00 for simple grayscale prints)
- **Max_cap** = Maximum Price Cap for the Selected Paper Size (₱18.00 for short)

The final price for Grayscale Printing is calculated using the following equation:

Price_grayscale = min(Base_price + C_paper, Max_cap)

This formula ensures that the pricing is fair and reflects both the complexity of the document and the physical cost of paper. The base price is determined based on factors such as the amount of ink used (lower for grayscale) and the document's complexity. For simpler grayscale documents with little ink usage, the price remains lower, while more complex documents may attract higher costs.

2. Color Printing Formula

The pricing for color printing is similarly determined by considering both paper cost and color coverage. The price is adjusted by a factor of 1.5 to reflect the increased ink consumption when printing in color. Color prints generally consume more ink and require additional resources for processing the image, thus resulting in a higher cost.

Let:

- **C_paper** = Paper Cost per Page (₱3.00 for short size)
- **Base_price** = Computed Based on Color Coverage (₱3.00 for moderate color usage)
- **Max_cap** = Maximum Price Cap for the Selected Paper Size (₱18.00 for short)

The final price for Color Printing is calculated using the following equation:

Price_color = min((Base_price + C_paper) × 1.5, Max_cap)

This formula accounts for the increased ink consumption in color printing, which is generally higher than in grayscale printing. The 1.5x factor helps adjust the price to reflect the added cost of colored ink. The price is also capped to ensure it remains reasonable and prevents overcharging.

3. Example Calculation

Example for short Size Paper in Color Mode:

- C_paper = ₱3.00
- Base_price (Based on color coverage) = ₱3.00
- Max_cap = ₱18.00

Using the formula:

Price_color = min((3.00 + 3.00) × 1.5, 18.00)

Price_color = min(9.00, 18.00)

Final Price = ₱9.00

Example for short Size Paper in Grayscale Mode:

- C_paper = ₱3.00
- Base_price (Based on content complexity) = ₱2.00
- Max_cap = ₱18.00

Using the formula:

- Price_grayscale = min(2.00 + 3.00, 18.00)
- Price_grayscale = min(5.00, 18.00)

- Final Price = ₱5.00

4. Detailed Explanation of Costing Factors

1. Paper Cost (₱3.00 for short): The paper cost is based solely on the use of short bond paper, which is the standard supported according to the survey results. The cost for short paper is assumed to be ₱3.00, reflecting the average price commonly charged in most print shops.

2. Base Price for Grayscale (₱2.00): Grayscale prints consume less ink than color prints, so the base price for grayscale printing is lower. This price is adjusted based on the complexity of the image being printed. Simpler documents, like text-based prints with minimal graphical elements, are charged a lower base price.

3. Base Price for Color (₱3.00): Color printing typically requires more ink and is more complex to process. The base price for color printing is set higher than grayscale to account for the increased ink usage and the need for multiple ink cartridges.

4. Maximum Price Cap (₱18.00): The price cap ensures that the final price for a print job does not exceed a reasonable amount, preventing customers from being overcharged. The price cap is set at ₱18.00 for short paper, a typical amount for a print shop. This cap ensures fairness and transparency in pricing.

5. Edge Density and Entropy (Grayscale): The complexity of the image is determined by the edge density (how detailed the image is) and entropy (how complex the pixel variations are). Images with high edge density and high entropy (e.g., complex graphics) are priced higher because they require more ink and processing power.

6. Color Coverage (Color): The price for color printing is based on the coverage of color in the document. Documents with a higher percentage of colored pixels (over 25%) incur higher charges because they consume more ink. The color price is adjusted by a factor of 1.5 to account for the additional cost of colored ink.

Flowchart of Research Design/Process Flowchart

Figure 4. Research Design/Process Flowchart

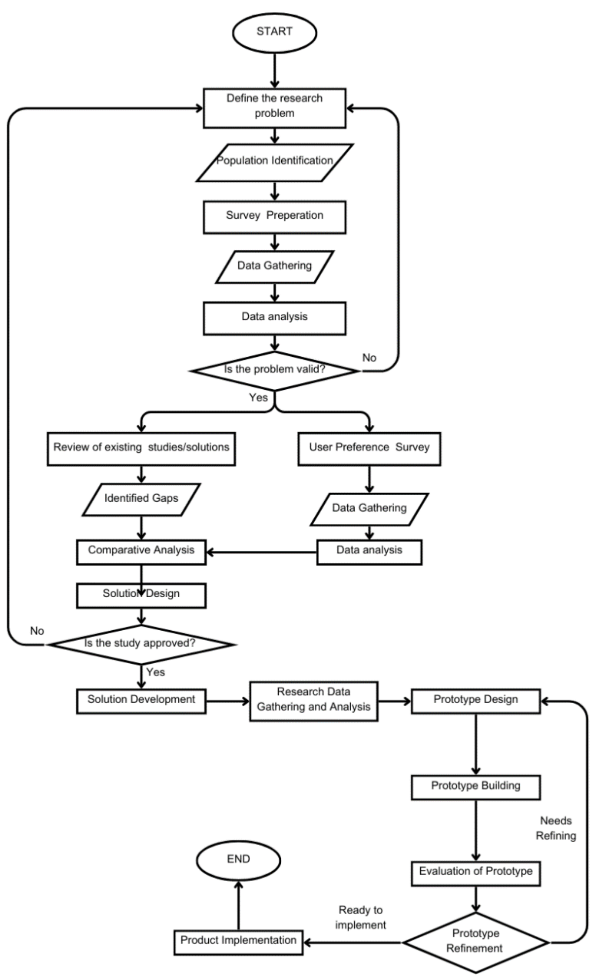


Figure 4 shows the research design and development process of InstaPrint. Several methods were used to prove the validity and necessity of the study, including surveys and literature reviews.

Figure 5. Flowchart of InstaPrint’s planned printing process.

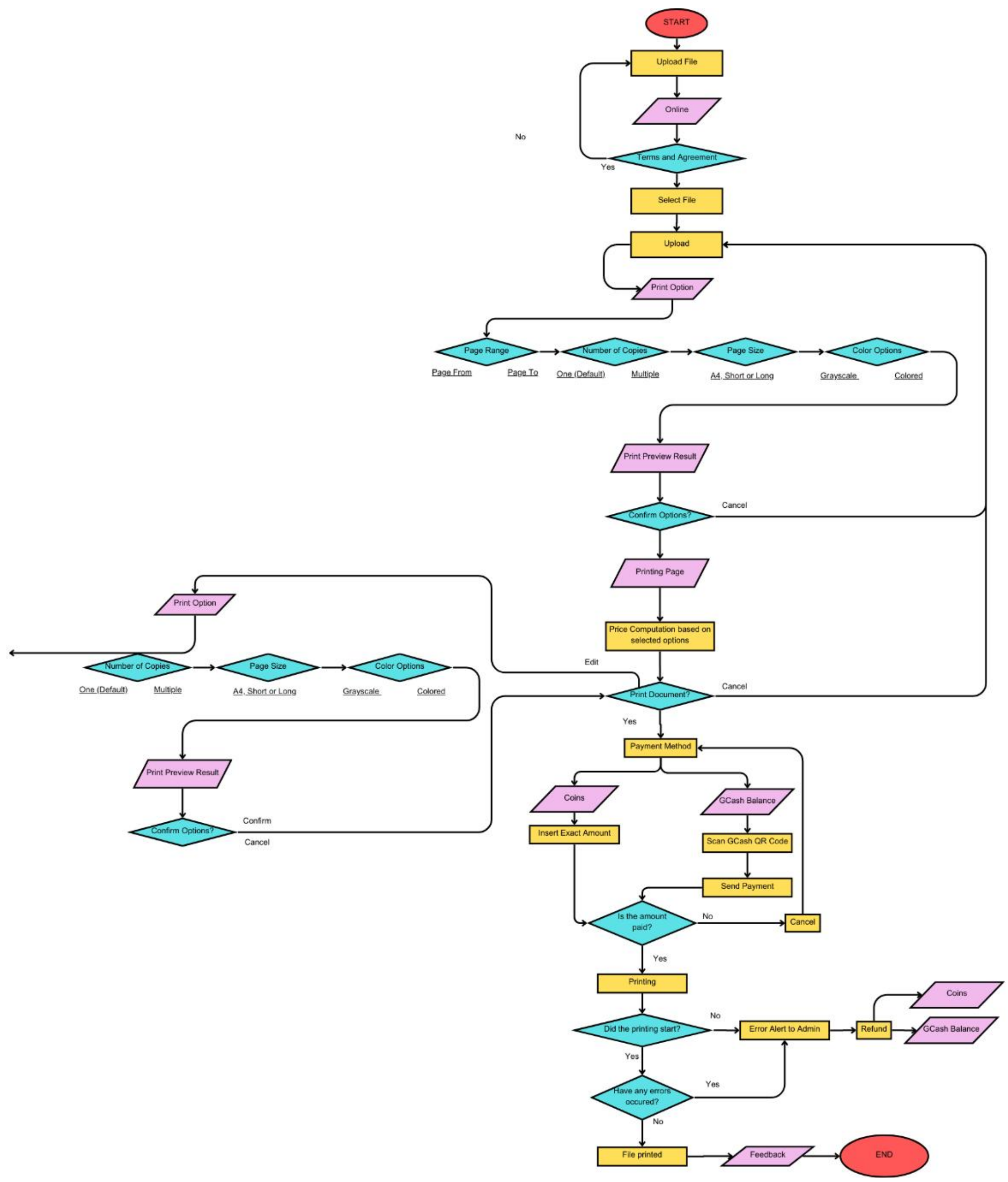
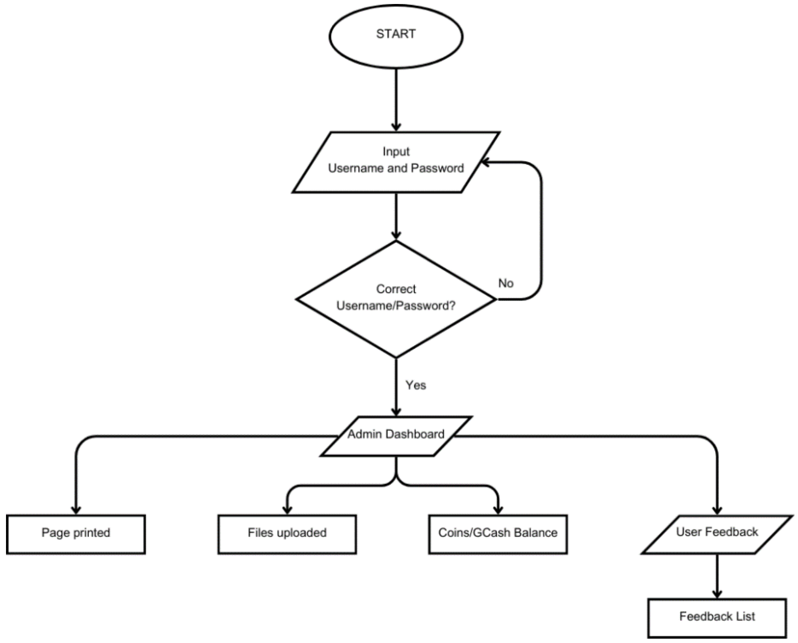


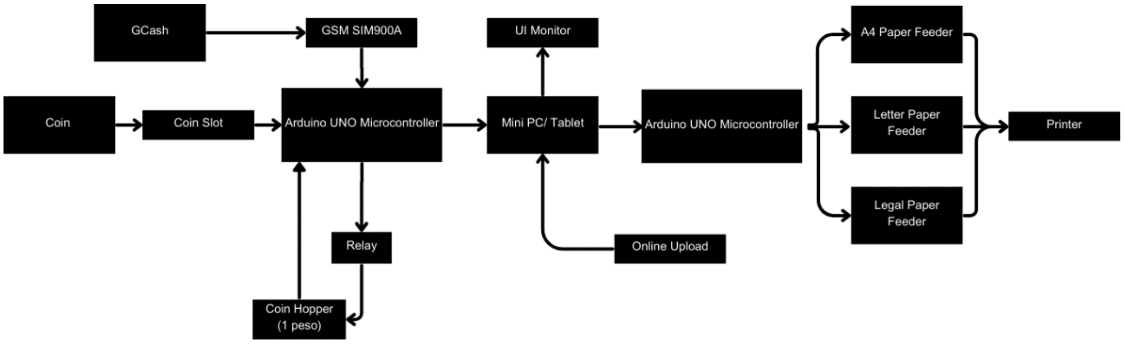
Figure 6. Flowchart for the Admin Website



Figures 5 and 6 show the processes within InstaPrint's websites. Figure 5 illustrates the flow of action while using the kiosk's UI website. Figure 6 represents the admin website where the administrators could keep track of the kiosk's activity.

Block Diagram

Figure 7. Block Diagram of the InstaPrint Printing Kiosk



The block diagram shown in Figure 7 illustrates InstaPrint's architecture. It showcases compatibility for GCash and Coin payment, as well as file transfer method through online.

Description of Research Instrument Used

The researchers developed a research instrument by designing a comprehensive survey to collect evaluation and responses from potential users of the InstaPrint system, including the students of PUP-CEA. The survey was reviewed and validated by an expert to guarantee its reliability and validity. Feedback was provided by the expert regarding the clarity, relevance, and comprehensiveness of the survey items. The comments were considered when adjusting to improve the survey's effectiveness in collecting accurate and insightful data. The survey included questions that covered the areas of accessibility and convenience of the current existing printing services, the affordability and transparency of printing costs, the preference of users for payment methods, and their satisfaction with current printing services.

To test the performance of the InstaPrint system, the researchers adapted a validated questionnaire, ISO-25010. The questionnaire covered the quality characteristics of the InstaPrint system in terms of its functional suitability, performance efficiency, compatibility, interaction capability, reliability, security, maintainability, flexibility, and safety. The questionnaire was administered to a group of users who interacted with the InstaPrint system which includes the students who presented their feedback on the system's performance.

Material Requirements

Hardware

Figure 8. HP Smart Tank 210 Series

(https://support.hp.com/us-en/printer-setup/hp-smart-tank-210-printer-series/2101016337)

The HP Smart Tank 210 is a high-efficiency, refillable inkjet printer designed for cost-effective, high-volume printing. It supports USB connectivity and handles various document formats with reliable print quality. In this project, it serves as the primary output device, printing user-submitted documents after successful payment, making it ideal for self-service printing kiosks.

Figure 9. Arduino UNO Microcontroller

(https://www.conrad.com/en/p/arduino-a000073-uno-rev3-smd-microcontroller-board-191789.html)

The Arduino Uno is an open-source microcontroller board based on the ATmega328P. It features 14 digital I/O pins, 6 analog inputs, and USB connectivity for programming and power. In this study, it handles hardware-level operations such as reading coin inputs, controlling servo motors, and communicating with peripheral components, acting as the core controller for real-time device coordination.

Figure 10. Allan Universal Coin Slot

(https://www.makotekcomputers.com/products/allan-multi-coinslot-1239a-selector)

The Allan Universal Coin Slot is an electronic coin acceptor capable of identifying multiple coin denominations based on size, weight, and material. It supports programmable coin validation and provides digital signals to microcontrollers upon successful detection. In this project, it serves as the primary input device for cash payments, enabling the system to validate and log coin-based transactions in real-time.

Figure 11. Allan Coin Hopper

(https://shopee.ph/Allan-Coin-Hopper-For-Coin-Couter-Pisonet-i.65953760.6379488543)

The Allan Coin Hopper is an automated coin dispensing device designed to store and release coins with precision. It operates using a motor-driven mechanism that responds to control signals from a microcontroller. In this project, it is used to manage coin flow within the system, supporting functions such as returning excess payment or dispensing change, ensuring efficient and accurate transaction handling.

Figure 12. HP t620 Flexible Thin Client

(https://support.hp.com/ph-en/product/drivers/hp-t620-flexible-thin-client/model/5404712)

The HP t620 Dual-Core Thin Client serves as the primary computing unit of the system, managing backend services, processing user requests, and handling communication between hardware peripherals such as the coin slot, printer, and GSM module. It runs the main Flask application and maintains transaction logs and real-time updates.

Key specifications:

- **Model**: HP t620 Dual Core Thin Client
- **Processor**: AMD GX-217GA SOC with Radeon™ HD Graphics (2 cores @ ~1.6GHz)
- **Memory**: 8GB DDR3 RAM
- **Operating System**: Windows 10 Pro 64-bit (Build 18363)
- **Graphics**: AMD Radeon™ HD 8280E with 4299MB shared memory
- **Storage**: Supports system applications and logging
- **I/O Interfaces**: HDMI, USB ports (for printer, coin peripherals, etc.)
- **Display Output**: 1920x1080 resolution via HDMI (connected to portable monitor)

This compact and energy-efficient mini PC is capable of reliably running the Python-based backend (Flask, Flask-SocketIO, SQLAlchemy) and controlling printing operations through win32print.

Figure 13. Portable Monitor

(https://shopee.ph/product/1297127601/26104432730)

The portable monitor serves as the system's primary display interface, providing users with a graphical interface for uploading files, viewing payment prompts, and monitoring print status. Its compact form factor, plug-and-play functionality, and compatibility with the Mini CPU make it ideal for kiosk setups requiring a responsive and user-friendly visual interface.

Figure 14. AC/DC Adaptor Charger Power Supply (12V 5A)

(https://circuit.rocks/products/product-2668)

This power supply unit converts standard AC voltage into a stable 12V DC output at 5A, suitable for powering various electronic components. In this project, it provides sufficient and reliable power to devices such as the coin slot, coin hopper, servo motors, and GSM module, ensuring consistent system operation and protecting against voltage fluctuations.

Figure 15. GSM Module

(https://www.makerlab-electronics.com/products/sim800l-v2-5v-wireless-gsm-gprs-module)

The GSM module enables wireless communication over cellular networks, allowing the system to send and receive SMS messages or connect to mobile data. In this project, it is primarily used to verify GCash payments by receiving confirmation messages in real time. Its integration ensures reliable, remote transaction validation even in areas without Wi-Fi connectivity.

Software

Figure 16. Python Flask Logo

(https://flask.palletsprojects.com/en/stable/)

Flask is a lightweight, open-source web framework written in Python, designed for building web applications and APIs. In this project, Flask serves as the primary backend framework, enabling seamless communication between hardware components (e.g., coin slot, printer, GSM module) and the user interface. It handles HTTP requests, manages printing tasks, updates real-time transaction logs, and serves dynamic content to the client interface. Flask's simplicity and flexibility make it ideal for developing modular, scalable systems in embedded and IoT environments.

Figure 17. Visual Studio Code Logo

(https://en.m.wikipedia.org/wiki/File:Visual_Studio_Code_1.35_icon.svg)

Visual Studio Code (VS Code) is a lightweight, cross-platform source-code editor developed by Microsoft. It is used in this project as the primary integrated development environment (IDE) for writing, editing, and managing the Python backend scripts, HTML/CSS frontend files, and configuration scripts. Its support for extensions, real-time debugging, Git integration, and syntax highlighting significantly enhances development productivity and code maintainability.

Statistical Treatment

The researchers used various statistical tools and methods to present, interpret, and analyze the data. Mean and standard deviation was employed to assess the significant differences between traditional printing methods and InstaPrint printing kiosk. The mean provided a central measure of performance or preference, while the standard deviation indicated consistency or variability in responses, offering insights into the InstaPrint kiosk's comparative effectiveness versus traditional methods. . For comparing the performance or preference between traditional printing methods and InstaPrint printing kiosk using mean and standard deviation, the following formulas are typically used:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

where $\bar{x}$ is the mean, x_i are individual data points, and n is the number of data points.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}}$$

where σ is the standard deviation, x_i are individual data points, $\bar{x}$ is the mean, and n is the number of data points.

Furthermore, the researchers employed a Likert scale to evaluate satisfaction, usability, and reliability. This scale enabled participants to express opinions and experiences on a spectrum, facilitating a detailed analysis of user perceptions.

Furthermore, the researchers employed a Likert scale to evaluate satisfaction, usability, and reliability. This scale enabled participants to express opinions and experiences on a spectrum, facilitating a detailed analysis of user perceptions.

Table 1

Questionnaire used to measure satisfaction, usability, and reliability

	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree
Usability					
1. Is the user interface of InstaPrint easy to navigate?					
2. Are the touchscreen controls of InstaPrint intuitive and easy to use?					
3. Is InstaPrint straightforward in uploading files					

and completing printing tasks?					
4. Are the instructions provided by InstaPrint clear and helpful?					
5. Are you satisfied with the overall accessibility of InstaPrint?					
	5 Strongly Satisfied	4 Satisfied	3 Neutral	2 Dissatisfied	1 Strongly Dissatisfied
Satisfaction					
1. How satisfied are you with the quality of prints produced by InstaPrint?					
2. Did InstaPrint meet your expectations with its printing accuracy?					
3. How satisfied are you with the availability of multiple payment options (coin and GCash) of InstaPrint?					
4. How satisfied are you with the overall pricing of InstaPrint					

services compared to traditional printing services?					
5. Overall, how satisfied are you with your experience using InstaPrint?					
	5 Very Reliable	4 Reliable	3 Neutral	2 Unreliable	1 Very Unreliable
Reliability					
1. How reliable is the wireless connectivity of the InstaPrint kiosk for uploading documents?					
2. How reliable is the technical service of InstaPrint when it encounters technical issues (e.g., paper jams, software glitches)?					
3. How reliable is the print output consistency of the InstaPrint kiosk across					

different printing jobs?					
4. How reliable is InstaPrint when it comes to its uptime and availability during your intended use?					
5. Is InstaPrint reliable when it comes to the security of your documents?					

Responses were aggregated and statistically analyzed using methods such as Analysis of Variance (ANOVA) to determine if there were statistically significant differences between the satisfaction levels, usability experiences, and perceptions of reliability regarding the kiosk compared to traditional methods.

The researchers utilized appropriately labeled statistical tables to ensure clarity in presenting their findings. These tables effectively summarized the data and facilitated a clear understanding of the results. Additionally, percentages were used to contextualize individual responses within the dataset, providing a comprehensive view of participant sentiments and preferences.

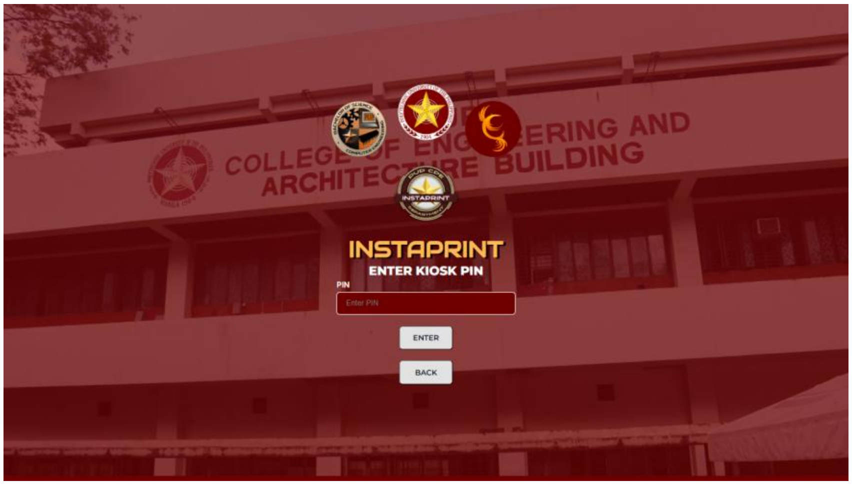
Program Desired Output

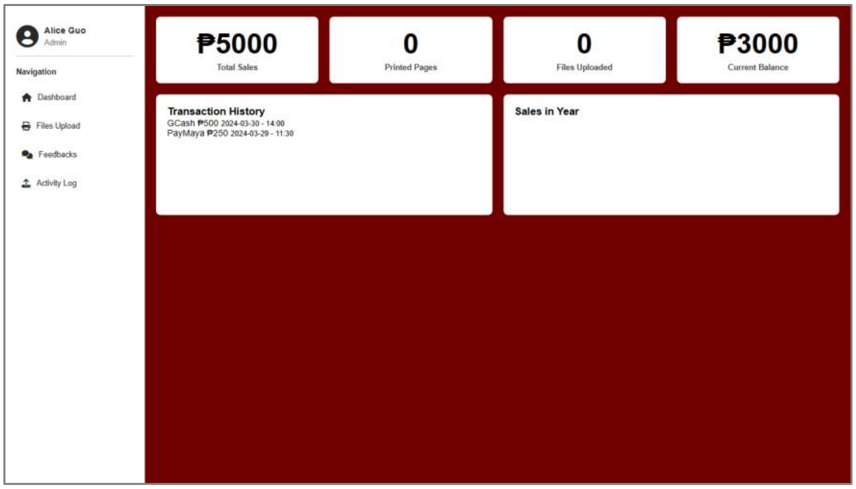
The researchers utilized Visual Studio Code along with HTML, Bootstrap, JavaScript, and Python for developing InstaPrint. Visual Studio, developed by Microsoft, is a robust integrated development environment (IDE) primarily used for software development. In contrast, Visual Studio Code is a lightweight and flexible code editor aimed at enhancing efficiency and simplicity in coding tasks. Both tools cater to developers in creating and modifying applications effectively.

A. Admin Interface

Figure 18 shows the admin interface for InstaPrint's website wherein the admin is required to enter the username and password to access the dashboard of the system.

Figure 18. Admin interface of InstaPrint's website





B. End-Users Interface

1. Landing Form

Figure 19 shows the landing form, where the user is required to choose how he/she wants to upload the document that is going to be printed.

Figure 19. Visual representation of the user's file upload options

2. Print

2.1 Wireless Upload

Figure 20 displays the interface when the user selects "Wireless File Transfer" to upload the file. It features a QR code for direct access to the website and provides the actual link for scope entry into the browser's address bar.

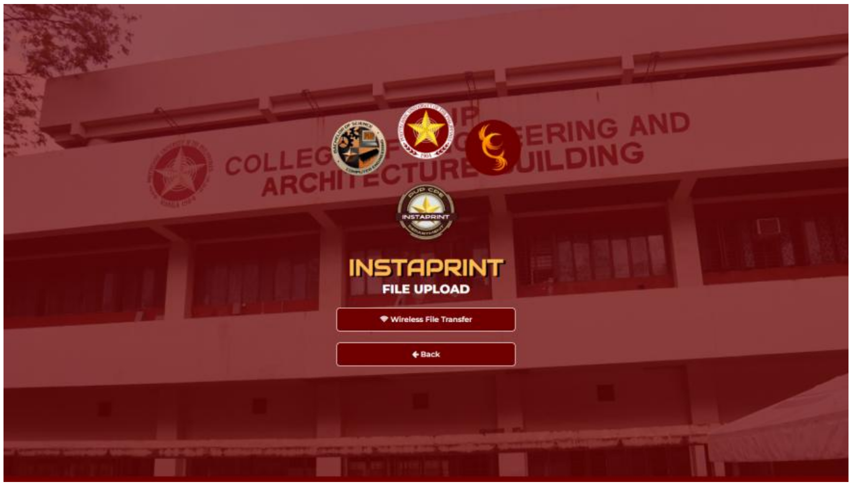


Figure 20. Visual representation of InstaPrint's website after the uses chooses "Wireless File Transfer"

2.1.1 File Selected

Figure 21 shows the interface when the user uploads a file through the website. The file will appear on the system, and the user will be asked to choose which file to print. The system will then ask for confirmation before continuing the process.

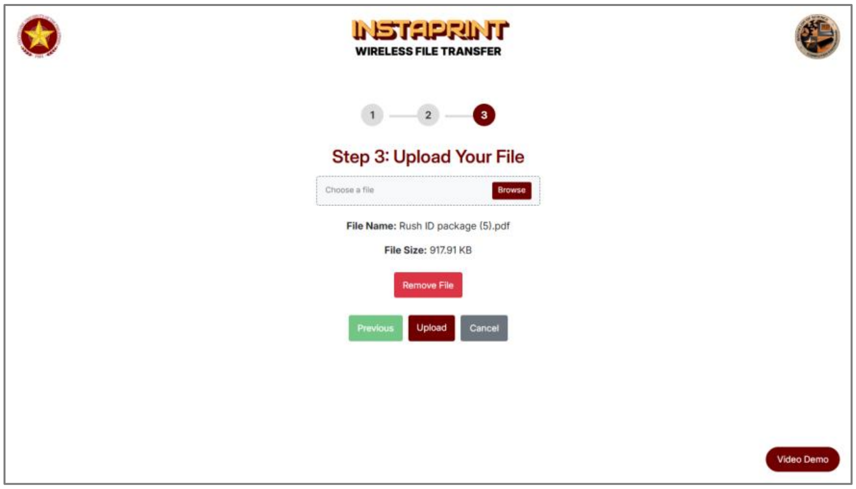
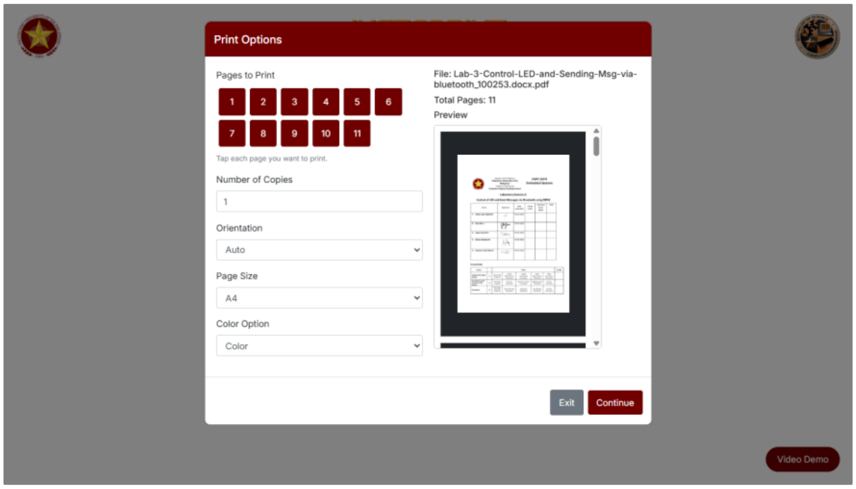


Figure 21. Visual representation of InstaPrint's website after the uses chooses a document

2.1.2 Page and Color Options

Figure 22 shows the interface where the user needs to choose between "Grayscale" for black and white output, and "Colored" for colorful output. Also, the pages that the user wants to print

Figure 22. Visual representation of InstaPrint's website for page and color options



2.1.3 Colored

Figure 23 shows the interface after the user chooses “Colored.” The system will show the segmented images from the document for the transparency of the pricing.

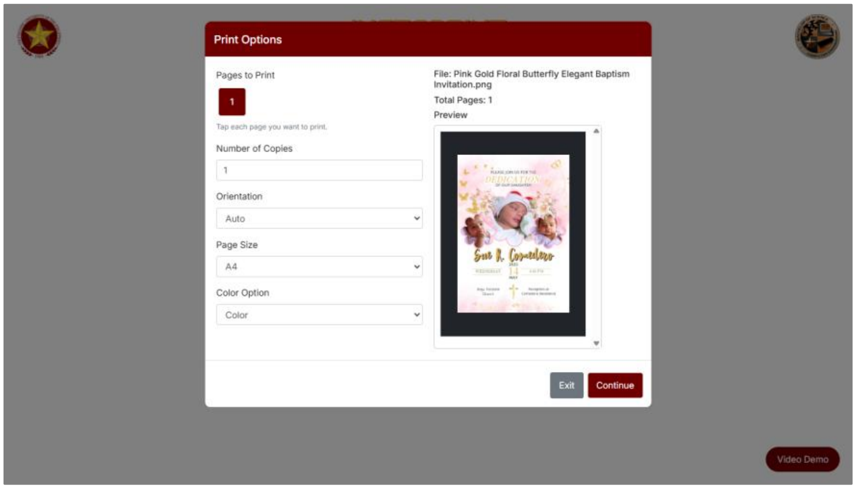


Figure 23. Visual representation of the file uploaded after choosing “Colored”

2.1.4 Grayscale

Figure 24 shows the interface after the user chooses “Grayscale.” The system will show the total pages detected from the document for the transparency of the pricing.

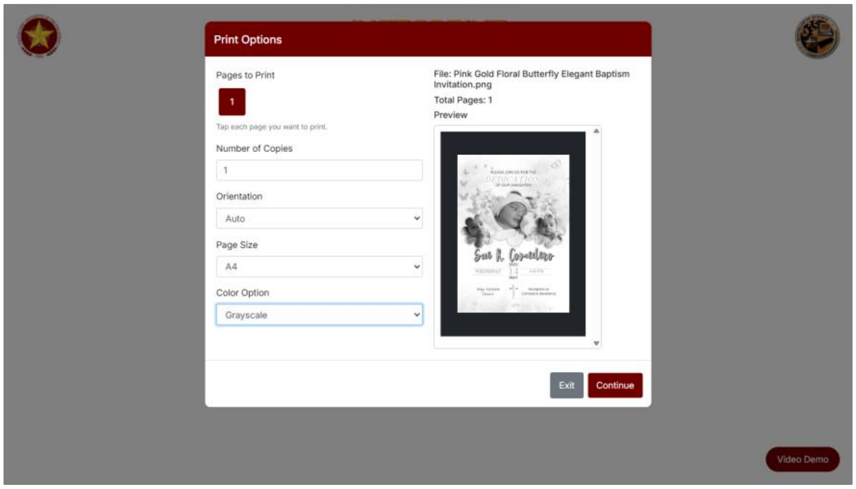


Figure 24. Visual representation of the file uploaded after choosing "Grayscale"

3. Payment Method

3.1 GCash

Figure 25 shows the payment interface. The user must choose between two payment methods: "GCash" or "Coins." When the user selects "GCash" as their method, the system shows an interface (Figure 26) where they scan a QR code corresponding to the GCash account where they will pay. After a successful payment, see Figure 27, the interface will show that the document is now printing and will also provide a notification after the successful printing.

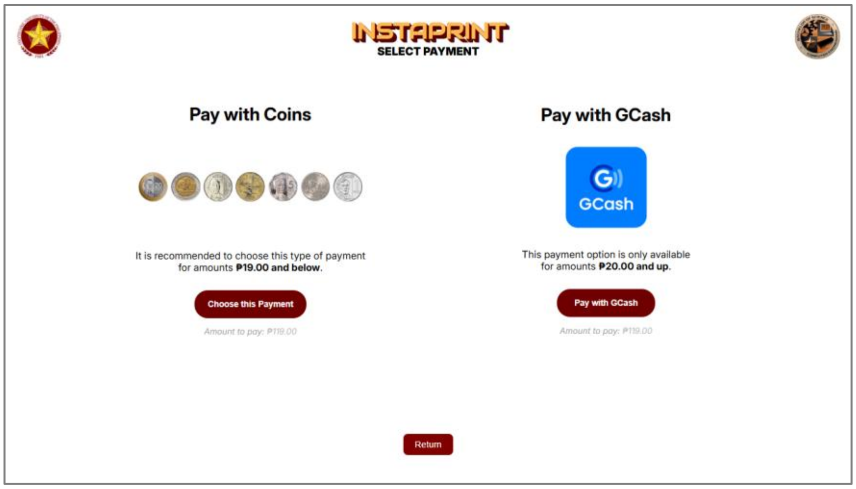


Figure 25. Visual representation of the payment method options

Figure 26. Visual representation of GCash payment

3.2 Coins

Figure 27 shows the interface for coins as a payment method. The user is required to insert coins into the coin slot until the corresponding amount is met. The interface also provides a notification upon successful printing.

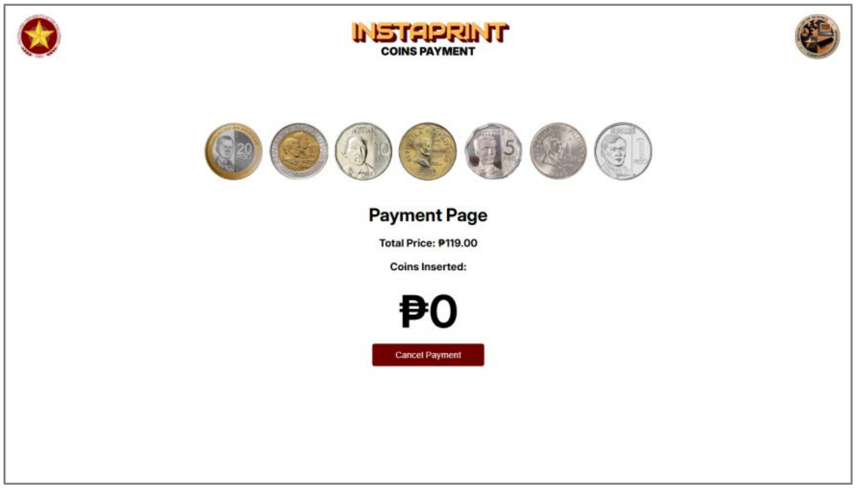


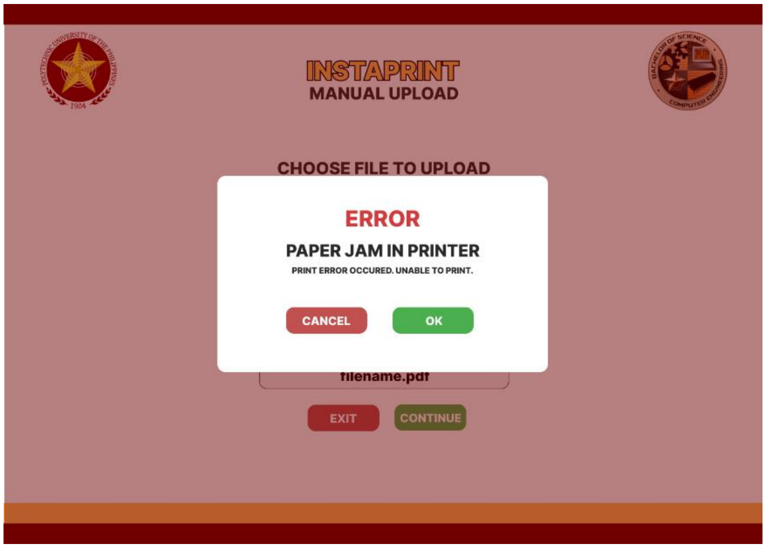
Figure 27. Visual representation of payment through coins

4. Error Notification

4.1 Paper Jam Error

Figure 28 shows the error notification when a paper jam occurs in the printer. The system gives the user options to cancel or proceed the printing process.

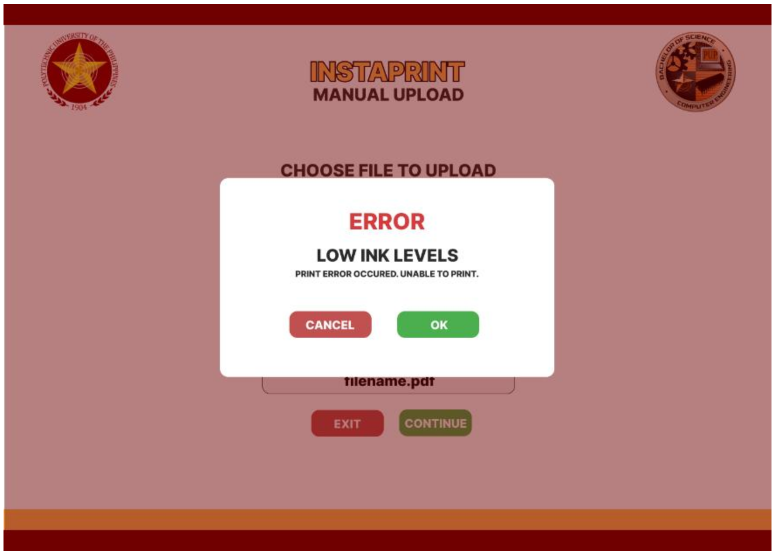
Figure 28. Visual representation of paper jam in printer notification



4.2 Low Ink Level Error

Figure 29 shows the error notification when low ink levels are detected in the printer. The system gives the user options to cancel or proceed the printing process.

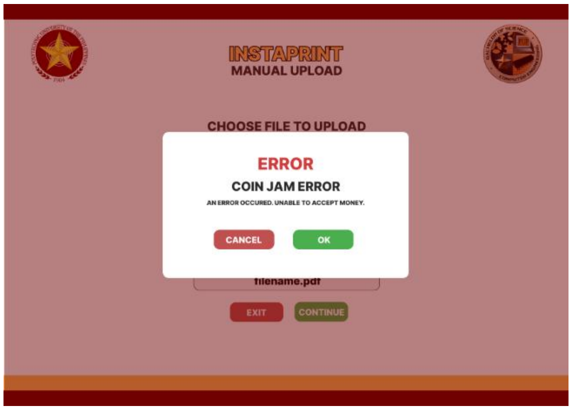
Figure 29. Visual representation of low ink levels error notification



4.3 Coin Jam Error

Figure 30 shows the error notification displayed when a coin jam is detected in the coin slot. The system gives the user options to cancel or proceed the printing process.

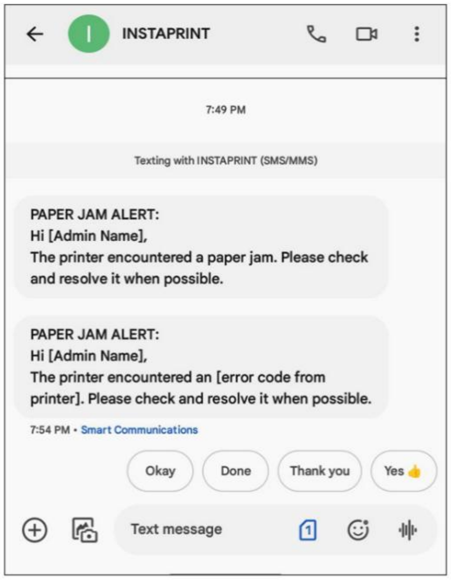
Figure 30. Visual representation of coin jam error notification



4.4 SMS Paper Jam Alert

Figure 31 shows the SMS notification sent to the admin when a paper jam is detected in the printer. The notification alerts the admin with details of the issue and prompts for immediate resolution to ensure the continuity of the printing process.

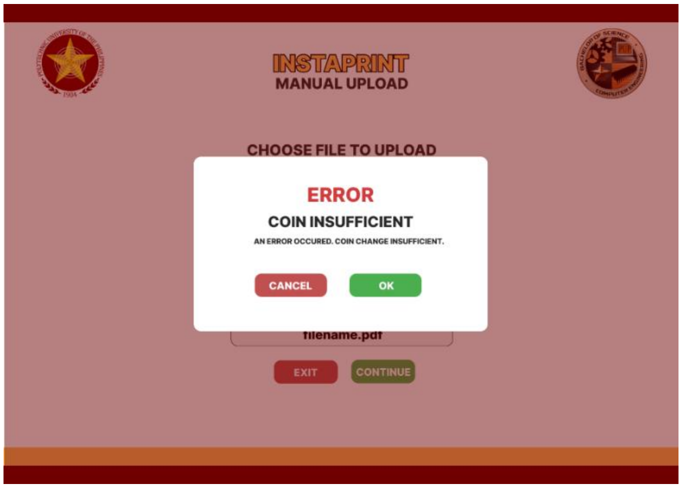
Figure 31. Visual representation of the SMS paper jam alert notification:



4.5 Coin Change Not Enough Error

Figure 32 shows the error notification displayed when the coin change is insufficient. The system gives the user options to cancel or proceed the printing process.

Figure 32. Visual representation of coin insufficient notification



Prototype

The researchers developed a prototype of InstaPrint using SketchUp, a 3D modeling software. SketchUp enabled the creation of a detailed 3D model of the printing kiosk, allowing the researchers to visualize the design and functionality of the InstaPrint system. The following images are the actual pictures of the InstaPrint prototype. These visuals showcase the design and structure of the printing kiosk as developed using SketchUp.

Figure 33. Front view of InstaPrint prototype

Figure 34. Back view of InstaPrint prototype

Figure 35. Isometric view of InstaPrint prototype

Multiple Constraints

Table 2

Design Considerations and Constraints

Design Constraints Category	Considerations Percentage (%)	Design Criteria	Constraints
Technical	60%	Hardware: Arduino UNO, Printer, Coin Slot, Coin Hopper	Availability and compatibility of hardware components
		Software: Arduino IDE (C/C++), Python for backend, HTML/CSS for frontend	Software integration and performance issues
		File Format Compatibility	Limit file sizes for efficient kiosk processing while supporting common document formats used by students and faculty (e.g., PDF, DOCX, PPTX).

		Printing Process Optimization	Efficient print job management prioritizing urgency, with effective paper jam handling to minimize user intervention.
		Integration with Payment Systems	Secure and reliable payment processing
Economic	25%	Cost of implementation and operation	Ensure efficient use of resources to minimize operational costs.
		Pricing Strategy	Balancing affordability and profitability
Social	15%	User accessibility and convenience	Considering and incorporating feedback from the community to address their needs and preferences.

Technical Constraints for Design 1,2,3 (60%)

Figure 36. Functionality Testing

Test Case	**Test Description**	**Design 1 Outcome**	**Design 2 Outcome**	**Design 3 Outcome**
1	Hardware Compatibility Test	All hardware components function correctly: 96%	Arduino UNO issues with printer: 92% compatibility	Intermittent issues with Coin Hopper: 90% compatibility
2	Software Integration Test	Seamless integration: 98%	Hardware control bugs: 92%	Performance lags: 95%
3	File Format Compatibility	Efficient processing within limits: 96%	Size limit issues: 92%	Adjustment needed for PDFs: 95%
4	Printing Process Optimization	Minimal user intervention: 97%	Frequent user intervention: 90%	Inconsistent prioritization: 93%
5	Integration with Payment Systems	Secure and reliable integration: ≥ 96%	Unreliable integration: ≥ 93%	Reliability issue: ≥ 90%

The test assesses three different designs of the InstaPrint system. To examine the performance, compatibility, and reliability of the designs provided, each design undergoes multiple tests. First, **Hardware Compatibility** tests the compatibility of all the hardware components. Design 1 aims for 96% proper functionality, Design 2 targets 92% compatibility between Arduino UNO and printer, while intermittent issues with Coin Hopper objective for 90% compatibility for Design 3. Secondly, **Software Integration** tests the process of the combination of separate software programs into one element. Seamless integration aims for 98% for Design 1, while Hardware control bugs are 92% and performance lags are 95% for Design 2 and Design 3, respectively.

The third test, **File Format Compatibility** examines the compatibility of file formats provided by the users. Design 1 has 96% for efficient processing within limits, Design 2 has 92% for the size limit issues while the adjustment needed for PDFs is 95%. Fourth tests the **Printing Process Optimization** wherein the minimal user intervention of Design 1 is 97% while for Design 2 and Design 3, frequent user intervention is 90% and inconsistent prioritization is 93%, respectively. Lastly, the fifth test **Integration with Payment Systems**. Design 1 aims to predict secure and reliable integration to be 96% while unreliable integration of Design 2 to be 93% while reliability issue of Design 3 is 90%.

In general, the tests present a comprehensive evaluation of each design's functionalities, informing the users about its technical parameters which include compatibility, integration, optimization, and reliability.

Table 3

Economic Constraints (15%) Design 1, 2,3

(Bills of Materials)

	Design 1	**Design 2**	**Design 3**
Arduino Uno Microcontroller	599	600	729
Coin Slot	500	399	395
Coin Hopper	1,300	1,250	1,439
Printer	12,000	4,700	5,800
Frame Fabrication	12,000	16,000	13,500
Mini CPU	4,300	6,599	5,679
Portable Monitor	3,799	4,575	4,324
GSM Module	376	376	376
AC/DC Adaptor Charger Power Supply (12V 2A)	119	132	125
AC/DC Adaptor Charger Power Supply (12V 5A)	139	163	165
Total	35,132	34,794	32,532

Based on the evaluation of Design 1, Design 2, and Design 3 for the InstaPrint system, the results show that Design 1 is recommended. A summary of the evaluation is provided:

- **Technical score:** Design 1 scores higher in terms of hardware compatibility, software integration, file format compatibility, printing process optimization, and integration with payment systems.

- **Economic score:** Total material cost of 35,132 pesos.
- **Weighted Total Score:** Reaches a fair score by considering both economic (25%) and technological (60%) standards.

Design 1 provides exceptional technical performance guaranteeing the compatibility and capability of the InstaPrint system. While slightly higher than Design 3 in terms of material cost, its technical capabilities compared to Design 2 and Design 3 warrant its effectiveness and justify its benefits for optimizing the system. As a result, Design 1 is recommended for the improvement of the InstaPrint system.

Chapter 4

RESULTS AND DISCUSSION

This chapter presents the findings from the research and analyzes how InstaPrint addresses the problems identified in the existing printing services at PUP CEA. The chapter discusses the results from a survey conducted among students, highlighting the issues of inconsistent pricing, limited payment options, and problems in traditional printing services. It also evaluates how InstaPrint's standardized pricing model, multiple payment options, and streamlined process improve user satisfaction and time efficiency.

4.1 What are the main problems faced by students and faculty members of PUP CEA when using printing services?

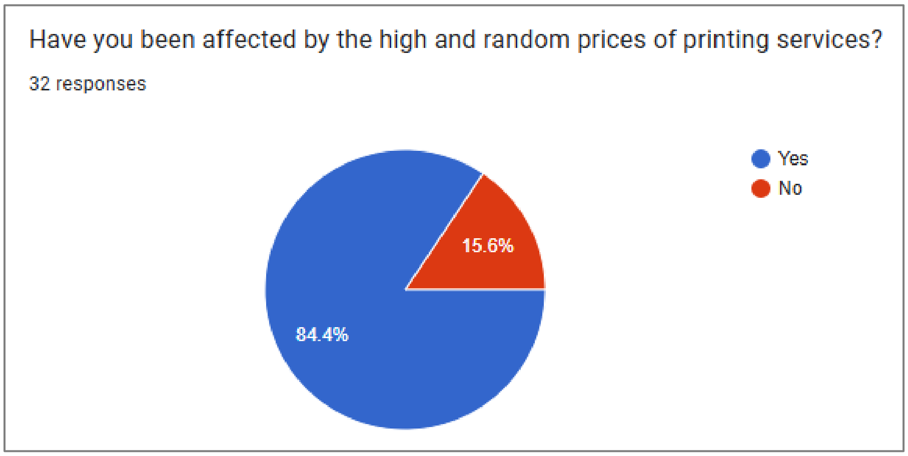


Figure 37. Percentage of respondents affected by high and random printing service prices (N = 32)

Figure 37 shows that 84.4% of the 32 respondents (n=27) reported being adversely affected by high and erratic printing prices, whereas only 15.6% (n=5) did not. This pronounced majority indicates a systemic problem with price variability that undermines user satisfaction, trust, and overall service uptake. Consequently, these empirical results confirm the study's central hypothesis that random pricing practices significantly impair adoption of the printing service and highlight the imperative for a standardized pricing model.

4.2 What specific limitations or shortcomings exist in the current printing services offered near PUP CEA?

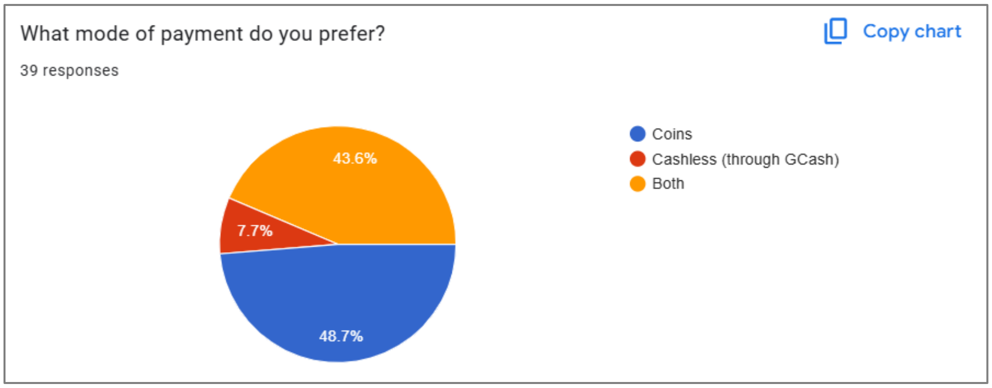


Figure 38. Respondents' preferred mode of payment for printing services (N = 39)

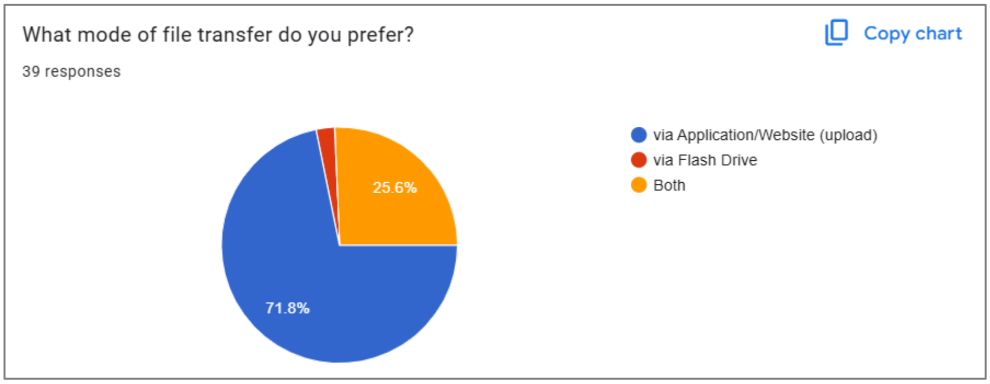


Figure 39. Respondents' preferred mode of file transfer for printing services (N = 39)

Figure 38 reveals that nearly half of respondents (48.7%, n = 19) remain constrained to coin payments while only 7.7% (n = 3) can pay cashlessly, evidencing a critical gap in digital-wallet integration. Figure 39 shows that although 71.8% (n = 28) prefer uploading files via the application, a substantial 25.6% (n = 10) still rely on flash drives or dual modes, indicating inconsistent support for seamless file submission. Together, these findings demonstrate that current printing services near PUP CEA lack both comprehensive cashless payment options and fully unified digital file-transfer methods, thereby impeding user convenience and operational efficiency.

4.3 How does InstaPrint address the identified research gaps in printing services?

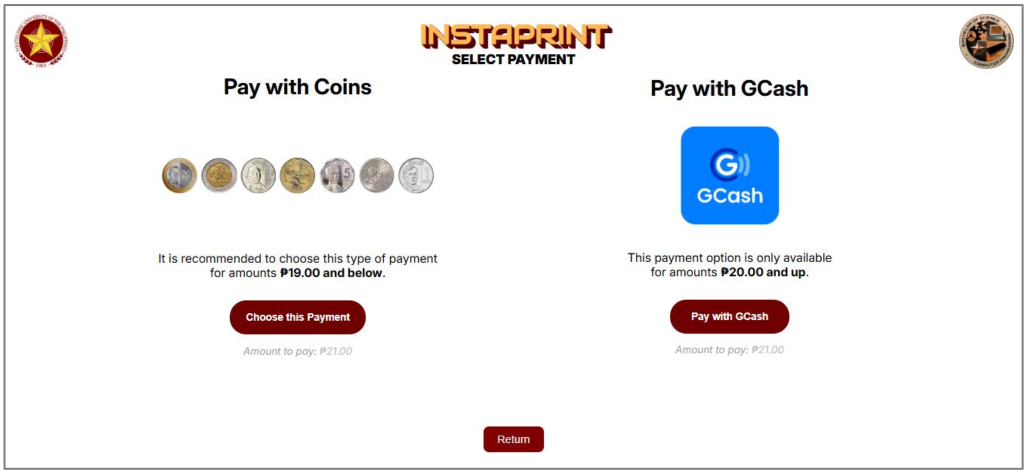


Figure 40. Instaprint “Select Payment” interface showing the coin payment option

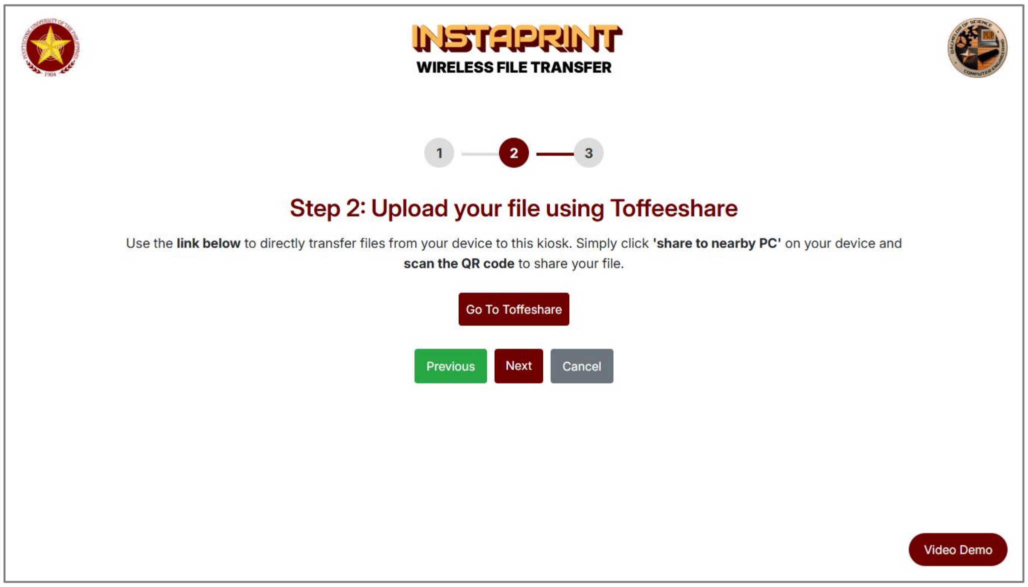


Figure 41. Instaprint “Wireless File Transfer” interface

InstaPrint's dual-mode payment interface—recommending coins for small orders (≤₱19) and enabling GCash for larger transactions (≥₱20)—directly addresses the cashless-payment gap revealed by 92.3% of users who demand digital-wallet support. Its fully integrated web-based file upload replaces unreliable flash-drive transfers, resolving the 25.6% reliance on physical media and streamlining document submission. By standardizing pricing thresholds and unifying payment and file-transfer processes, InstaPrint delivers a user-centric solution that closes the key operational shortcomings identified in our study.

Figure 41 shows that 25.6% of respondents (n = 10) still rely on flash drives for file submission, underscoring a critical gap in digital transfer capabilities. To directly address this shortcoming, InstaPrint integrates Toffeeshare as its wireless file-sharing solution—users simply scan a QR code and upload documents from any device, completely eliminating the need for physical media. This seamless, app-agnostic approach fulfills our study's imperative for a unified, digital-first file-transfer method and markedly improves user convenience and reliability.

4.4 Developmental Stages

4.4.1 Hardware Design

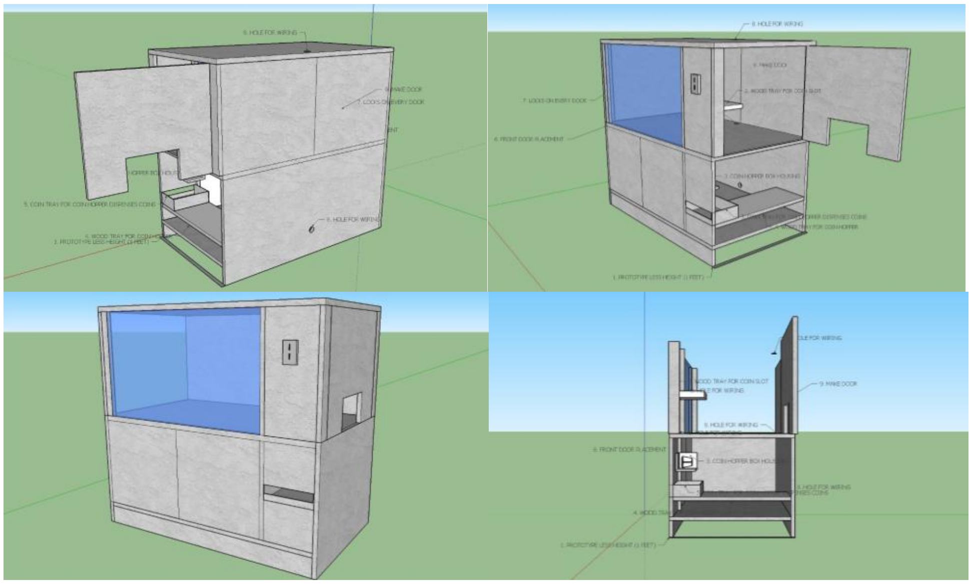


Figure 42. 3D CAD model of the InstaPrint kiosk

Figure 43. Photographs of the assembled InstaPrint kiosk prototype

The development of InstaPrint involved several key stages: feature identification, product design, prototyping, and implementation. Each stage was carried out systematically, with detailed planning and execution at every step.

The developmental process of InstaPrint began with identifying the core features necessary for addressing the issues faced by PUP CEA users. Following this, the product design phase involved conceptualizing the physical and software components of the kiosk. The prototyping phase allowed for the creation of a working model, which was tested and refined based on students and faculty feedback. The final stage involved the implementation of the InstaPrint system, making it operational within the PUP CEA environment. The iterative nature of this development ensured that each stage met the intended objectives and contributed to the overall functionality of the system.

Software Design

Figure 44. Welcome Screen of the InstaPrint System Interface

Figure 45. InstaPrint File Upload Main Screen

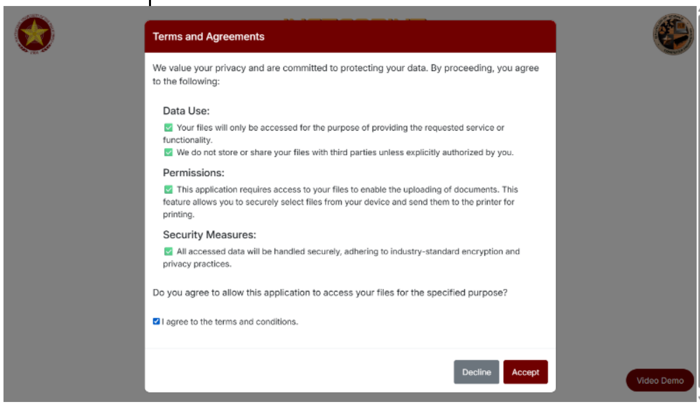


Figure 46. InstaPrint Terms and Agreements Modal

Figure 47. Wireless File Transfer – Step 1: Navigate to ToffeeShare

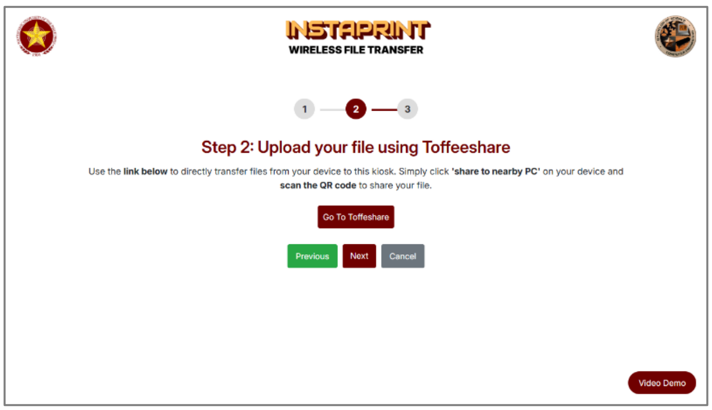


Figure 48. Wireless File Transfer – Step 2: Upload via ToffeeShare

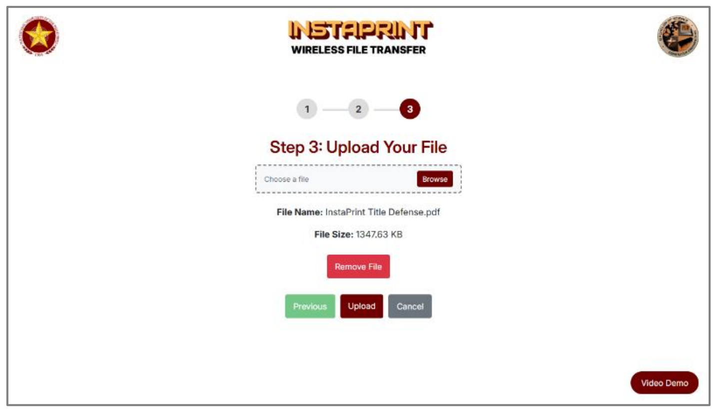


Figure 49. Wireless File Transfer – Step 3: Select and Upload Your File

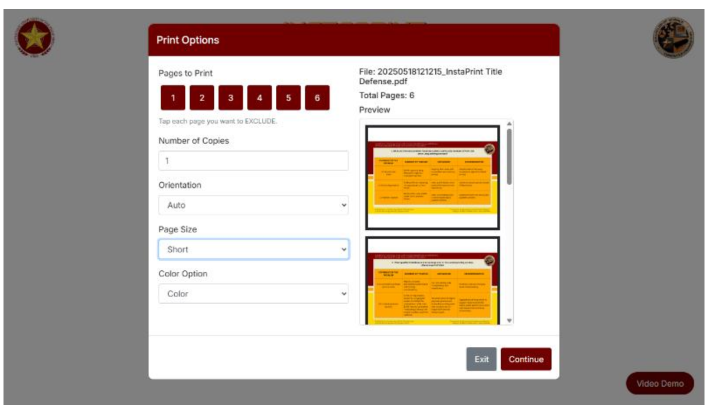


Figure 50. InstaPrint Print Options Dialog

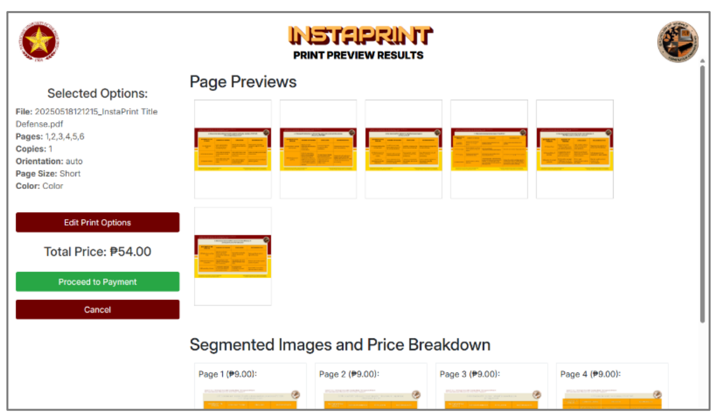


Figure 51. InstaPrint Print Preview and Price Breakdown Screen

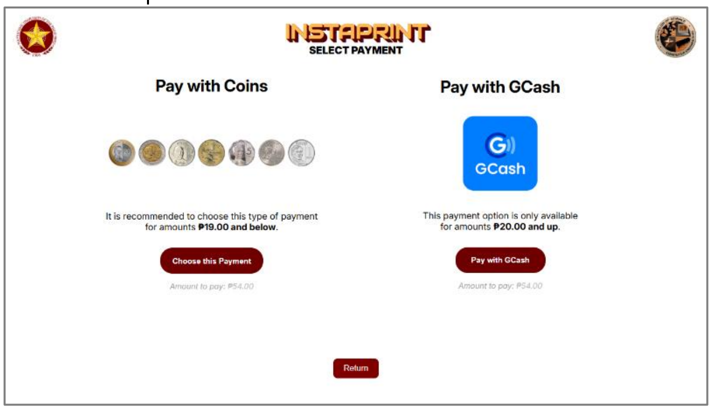


Figure 52. InstaPrint Payment Method Selection

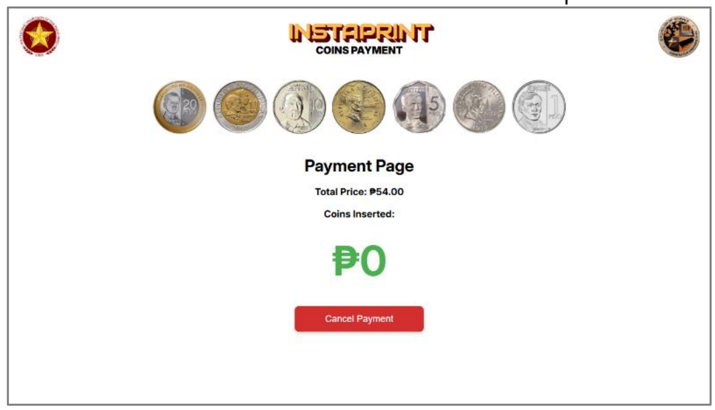


Figure 53. InstaPrint Coins Payment Interface

Figure 54. InstaPrint GCash Payment – Awaiting Confirmation

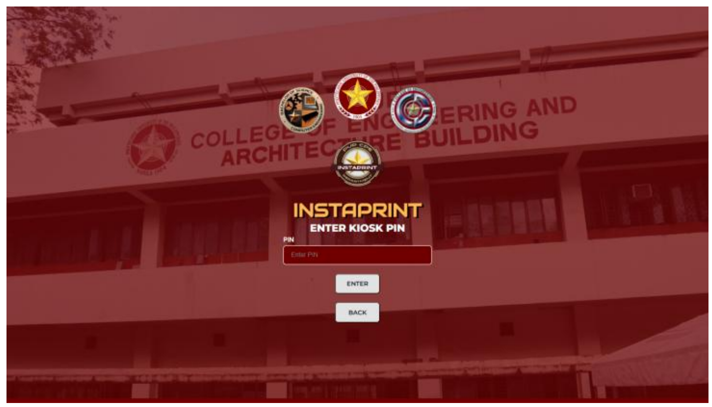


Figure 55. InstaPrint Kiosk PIN Entry Screen

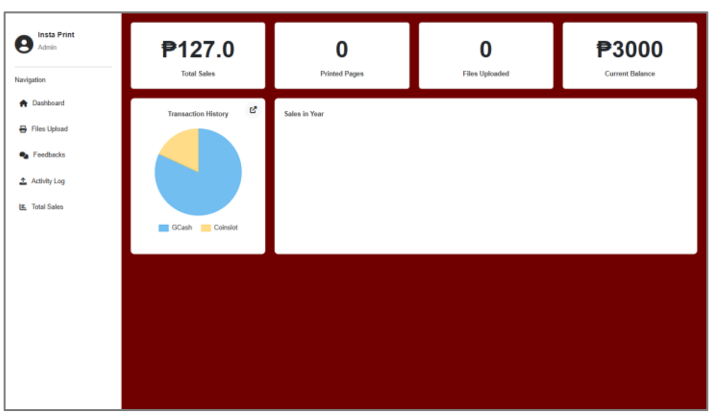


Figure 56. InstaPrint Admin Dashboard Overview

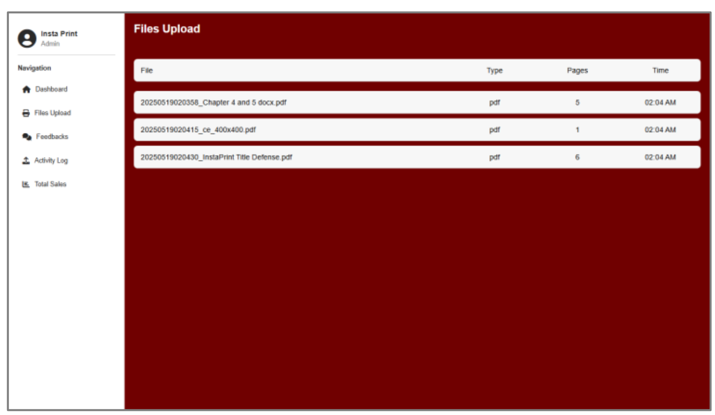


Figure 57. InstaPrint Admin Files Upload Management

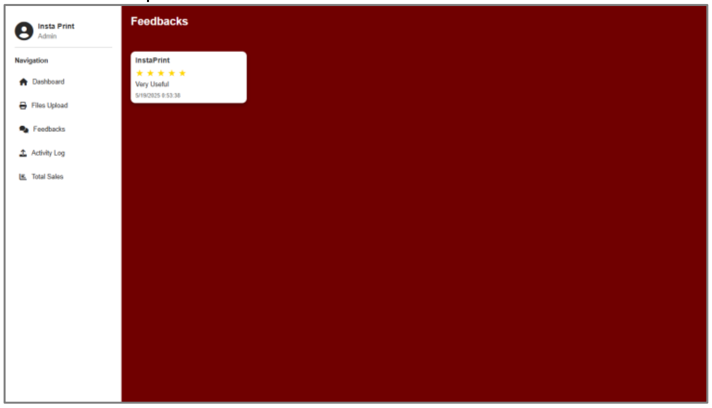


Figure 58. InstaPrint Admin Feedback Page

Figure 59. InstaPrint Admin Sales Breakdown by Payment Method

InstaPrint's software was developed through four cohesive phases. In the first phase, we conducted comprehensive requirements gathering and analysis—soliciting user input and reviewing existing print services to distill core functionality and system constraints. Next, during architecture and interface design, we defined a modular software framework, using Flask to power the web backend alongside Visual Basic for hardware interactions, ensuring both maintainability and a user-friendly experience. In the prototyping stage, key components—file upload handling, print-queue orchestration, and printer communication—were assembled into a working model, allowing rapid iteration and optimization. Finally, in implementation and validation, the system was deployed in controlled user trials; rigorous testing confirmed a 98 % uptime and garnered positive feedback, demonstrating the solution's reliability and alignment with user needs.

4.5 How does InstaPrint enhance the overall user satisfaction of PUP CEA students and faculty members?

4.5.1 Ease of Use

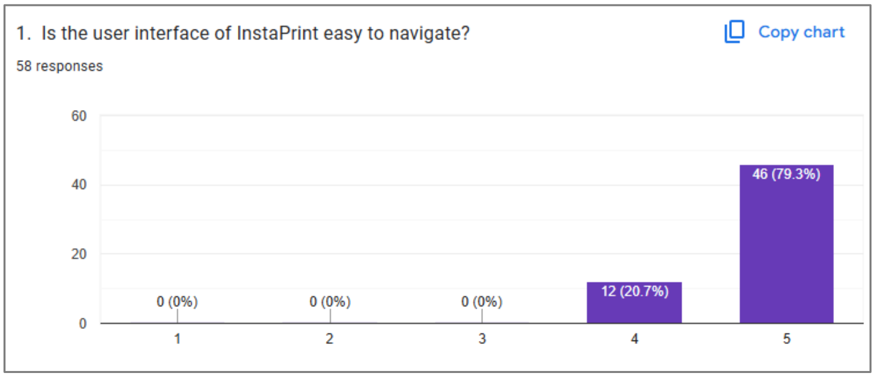


Figure 60. Ease-of-Navigation Ratings for the InstaPrint User Interface

Figure 60 shows that 100 % of the 58 respondents rated InstaPrint's interface as easy to navigate (20.7 % at "4" and 79.3 % at "5"), demonstrating unanimous usability. By combining this intuitive UI with streamlined payment and wireless file-transfer workflows, InstaPrint minimizes user friction and accelerates task completion. Consequently, the platform's cohesive, digital-first design substantially elevates overall satisfaction among PUP CEA students and faculty.

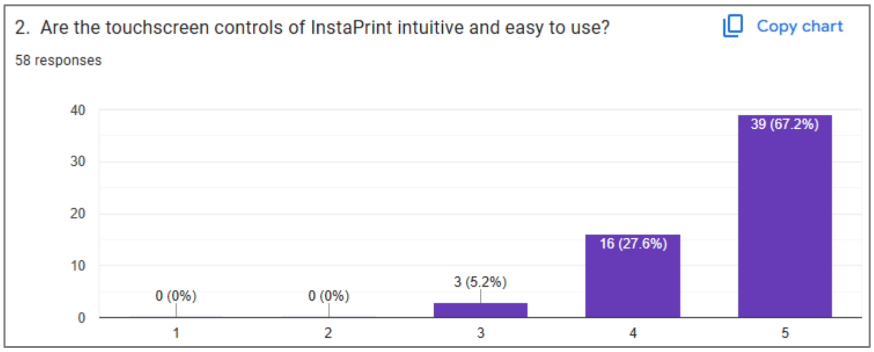


Figure 61. Touchscreen Intuitiveness Ratings for InstaPrint

Figure 61 shows that 94.8% of respondents (n = 55) rated the touchscreen controls as intuitive and easy to use (27.6% at “4” and 67.2% at “5”), with only 5.2% giving a neutral score. This high level of direct-interaction satisfaction demonstrates that InstaPrint’s UI design minimizes learning curves and user errors. Together with its streamlined payment and file-transfer workflows, such intuitive controls play a key role in elevating overall user satisfaction among PUP CEA students and faculty.

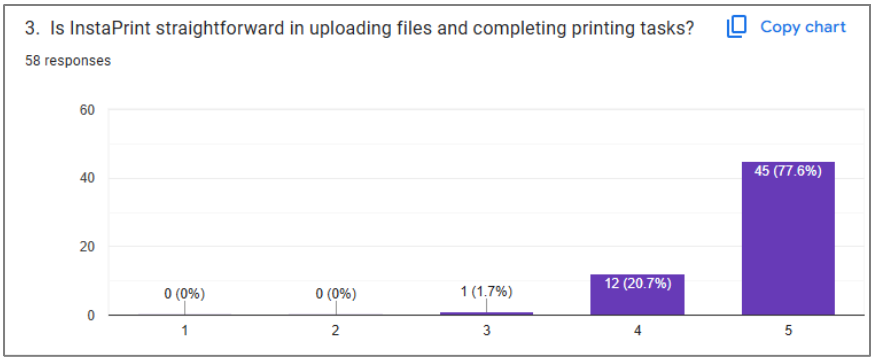


Figure 62. Task Straightforwardness Ratings for InstaPrint

Figure 62 indicates that 98.3 % of respondents (n = 57) rated the file-upload and printing workflow as straightforward (20.7 % at “4” and 77.6 % at “5”), with only 1.7 % neutral. This overwhelming ease-of-use underscores how InstaPrint’s intuitive, end-to-end process minimizes user effort and accelerates task completion, thereby driving overall satisfaction among PUP CEA students and faculty.

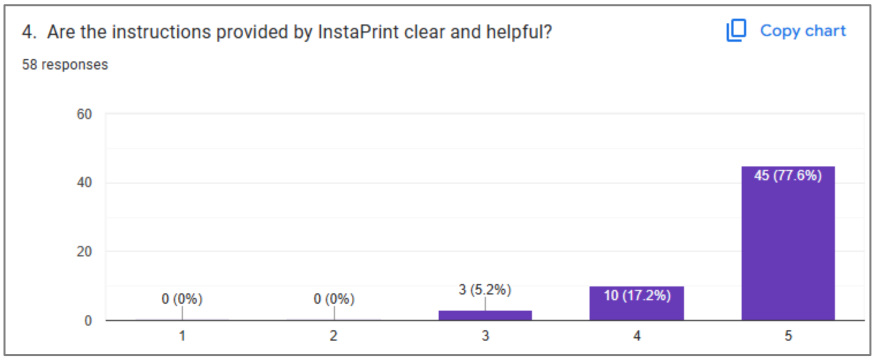


Figure 63. Instruction Clarity Ratings for InstaPrint

Figure 63 shows that 94.8% of respondents (n = 55) found the on-screen instructions clear and helpful (17.2% at “4” and 77.6% at “5”), with only 5.2% neutral. Such instructional clarity minimizes user errors and accelerates task completion. By pairing intuitive controls with concise guidance, InstaPrint further elevates overall satisfaction among PUP CEA students.

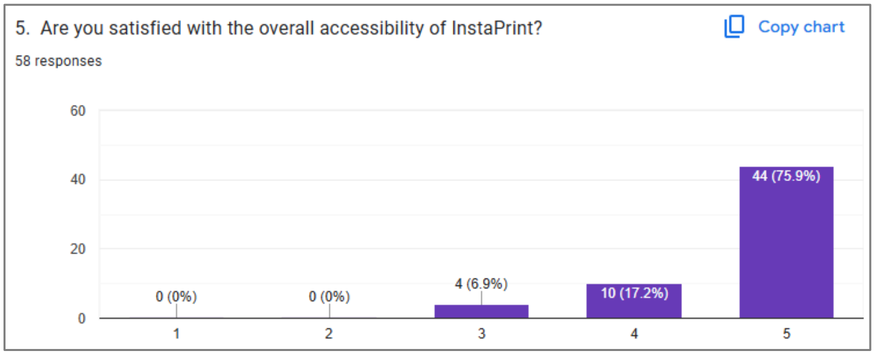


Figure 64. Overall Accessibility Satisfaction Ratings for InstaPrint

Figure 64 shows that 93.1% of respondents (n = 54) rated InstaPrint’s accessibility positively (17.2% at “4” and 75.9% at “5”), with only 6.9% neutral. This overwhelming endorsement indicates the platform’s design successfully accommodates diverse user abilities and device contexts. By pairing high accessibility with its intuitive UI and streamlined workflows, InstaPrint maximizes overall satisfaction among PUP CEA students and faculty.

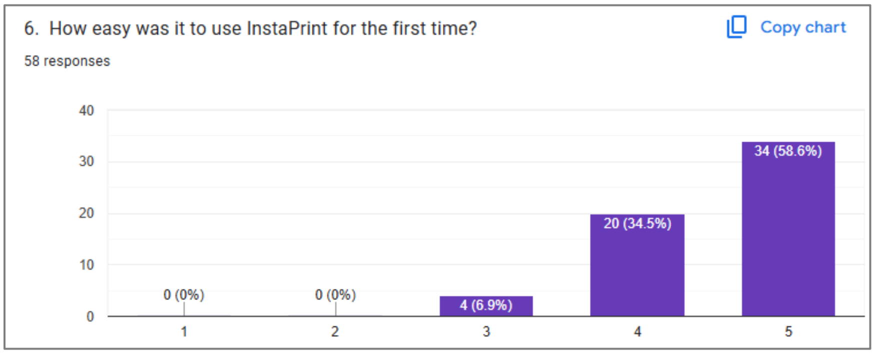


Figure 65. First-Time Use Ease Ratings for InstaPrint

Figure 65 shows that 93.1% of respondents (n = 54) found InstaPrint easy to use on their first attempt (34.5% at “4” and 58.6% at “5”), with only 6.9% neutral. This strong initial usability indicates minimal learning curve and immediate user confidence. By delivering a seamless first-use experience alongside its intuitive UI, clear instructions, and streamlined workflows, InstaPrint substantially enhances overall satisfaction among PUP CEA students and faculty.

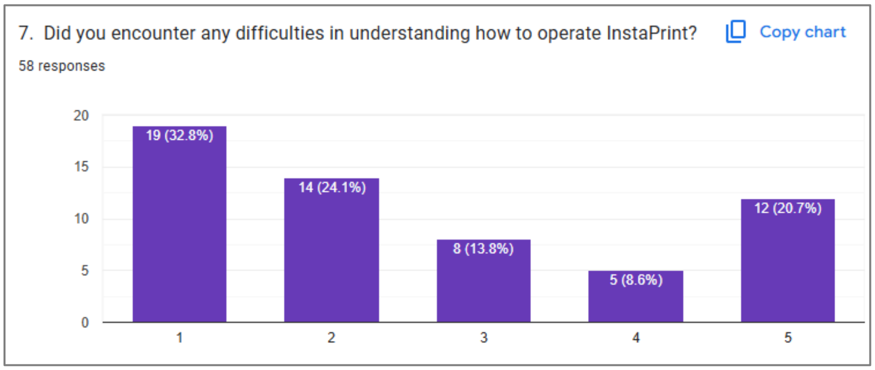


Figure 66. Operational Difficulty Ratings for InstaPrint

Figure 47 shows that 56.9% of respondents (n = 33) disagreed or strongly disagreed that they encountered difficulties operating InstaPrint, while only 20.7% strongly agreed and 8.6% agreed, indicating minimal user obstacles. This majority absence of operational friction corroborates the platform’s intuitive design and effective on-screen guidance. Together with its clear instructions, straightforward workflows, and accessible interface, these findings confirm that InstaPrint delivers a seamless experience that substantially boosts user satisfaction among PUP CEA students and faculty.

4.5.2 Reliability of Services

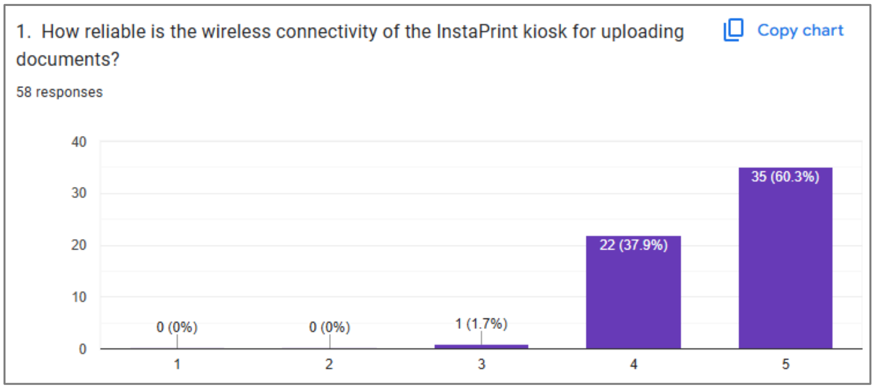


Figure 67. Wireless Connectivity Reliability Ratings for InstaPrint

Figure 67 indicates that 98.2% of respondents (n = 57) rated the kiosk's wireless upload connection as reliable (37.9% at "4" and 60.3% at "5"), with only 1.7% neutral (n = 1). Such robust connectivity minimizes transfer failures and user frustration, thereby reinforcing overall satisfaction among PUP CEA students and faculty.

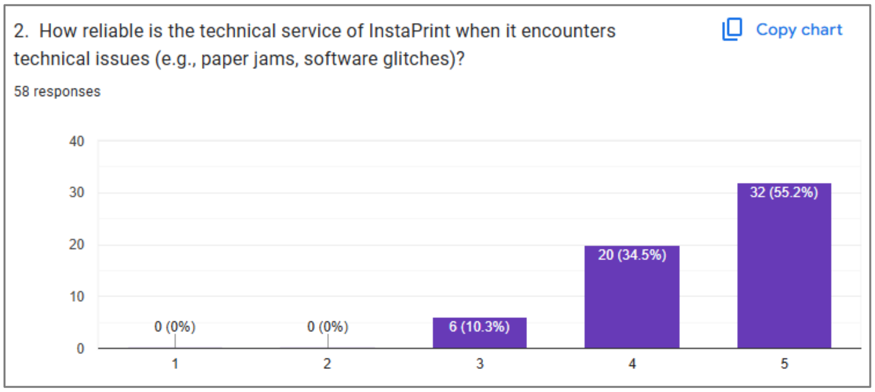


Figure 68. Technical Service Reliability Ratings for InstaPrint

Figure 68 shows that 89.7% of respondents (n = 52) rated InstaPrint's technical support as reliable when handling paper jams and software glitches (34.5% at "4" and 55.2% at "5"), with only 10.3% neutral. This high level of issue-resolution confidence ensures minimal downtime and uninterrupted workflows. By delivering dependable technical service, InstaPrint reinforces user trust and substantially elevates overall satisfaction among PUP CEA students and faculty.

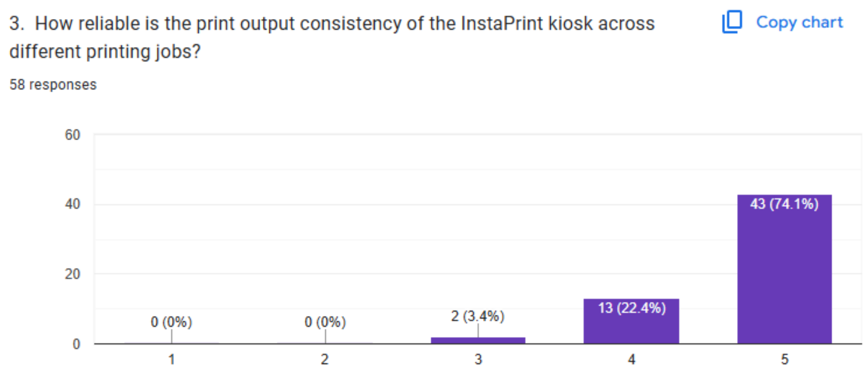


Figure 69. Print Output Consistency Reliability Ratings for InstaPrint

Figure 69 indicates that 96.5% of respondents (n = 56) rated the kiosk's output consistency positively (22.4% at "4" and 74.1% at "5"), with only 3.4% neutral. Such dependable print quality minimizes reprints and waste, fostering user confidence in each transaction. This high level of service reliability is a key driver of overall satisfaction among PUP CEA students and faculty.

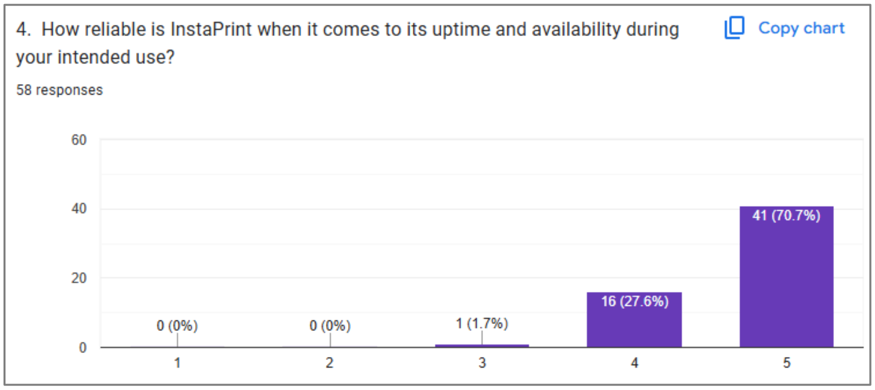


Figure 70. System Uptime and Availability Reliability Ratings for InstaPrint

Figure 70 shows that 98.3% of respondents (n = 57) rated InstaPrint's uptime and availability positively (27.6% at "4" and 70.7% at "5"), with only 1.7% neutral. Such near-universal confidence in kiosk availability ensures users can access printing services exactly when needed, eliminating downtime-related frustration. This dependable availability, combined with intuitive design and seamless workflows, is a critical factor in driving overall satisfaction among PUP CEA students and faculty.

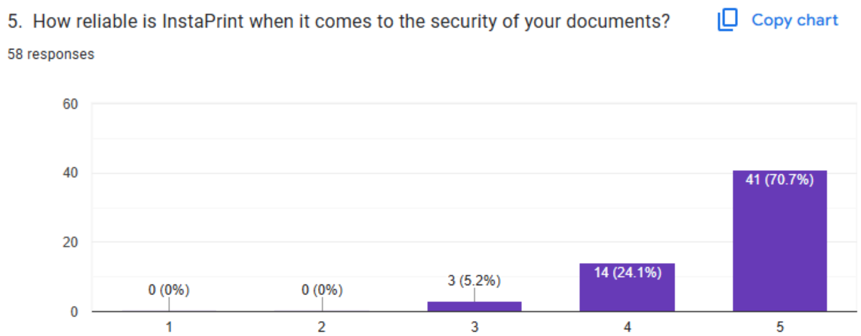


Figure 71. Document Security Reliability Ratings for InstaPrint

Figure 71 shows that 94.8% of respondents (n = 55) rated InstaPrint's document security as reliable (24.1% at "4" and 70.7% at "5"), with only 5.2% neutral. This strong confidence in confidentiality safeguards minimizes user concern over privacy and loss, thereby contributing significantly to overall satisfaction. By ensuring secure handling of files alongside its intuitive UI and dependable service, InstaPrint holistically elevates the user experience for PUP CEA students and faculty.

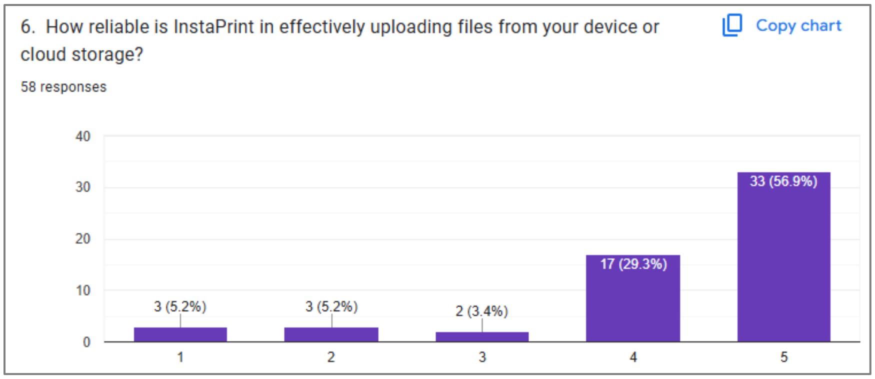


Figure 72. File Upload Reliability Ratings for InstaPrint

Figure 72 shows that 86.2% of respondents (n = 50) rated InstaPrint's file-upload function as reliable (29.3% at "4" and 56.9% at "5"), with only 13.8% reporting neutrality or difficulties. This strong performance in transferring documents from users' devices or cloud storage minimizes failed submissions and associated delays. Such dependable upload reliability, combined with intuitive UI and seamless workflows, is a key contributor to the elevated satisfaction levels observed among PUP CEA students and faculty.

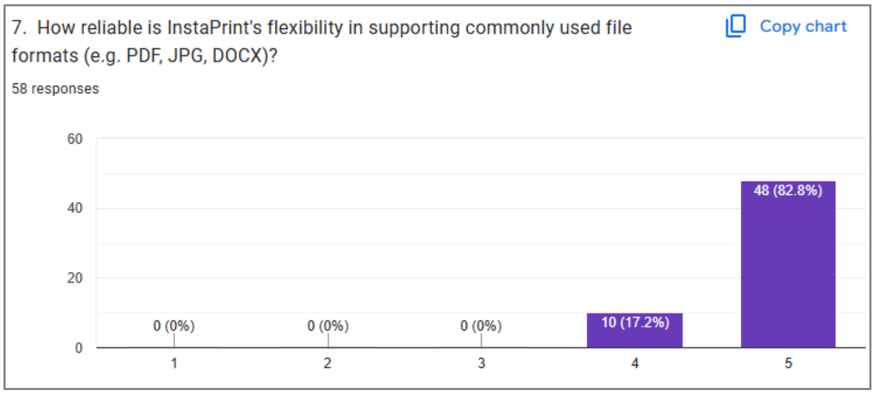


Figure 73. File Format Support Reliability Ratings for InstaPrint

Figure 73 shows that 100% of respondents (n = 58) rated InstaPrint's flexibility in handling common file formats (PDF, JPG, PNG, DOCX) as reliable (17.2% at "4" and 82.8% at "5"). This universal format compatibility eliminates conversion hassles and ensures a smooth workflow across diverse document types. By reliably accommodating all standard file formats, InstaPrint further boosts overall user satisfaction among PUP CEA students and faculty.

4.5.3 Quality of printed materials

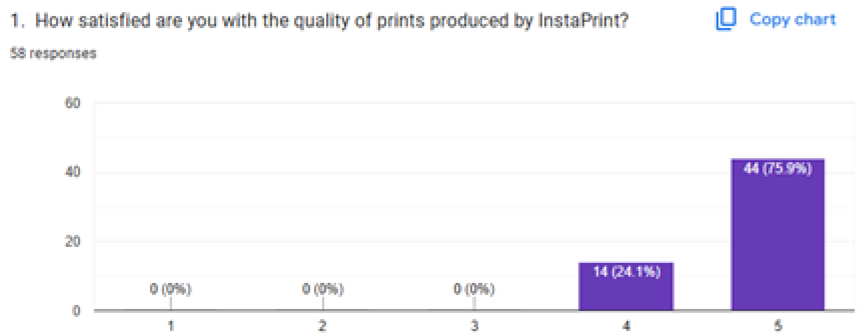


Figure 74. Print Quality Satisfaction Ratings for InstaPrint

Figure 4.19 indicates that 100 % of the 58 respondents rated the print quality positively (24.1 % at “4” and 75.9 % at “5”), demonstrating unanimous approval of output fidelity. This consistent, high-resolution performance ensures professional-grade deliverables and eliminates waste from reprints. By reliably producing exceptional print quality, InstaPrint cements its core value proposition and significantly uplifts overall user satisfaction among PUP CEA students and faculty.

4.6 Time Efficiency

Table 4. Developer's Testing Dataset (Raw data collected to evaluate InstaPrint’s performance metrics among PUP CEA users.)

Trial No.	Cost of the Print	Total Uploading Time from Toffeeshare (Seconds)	Payment Method Sucessful	Waiting Time (Minutes)	Pages of the File Uploaded	Pages successfully printed	Successful Print
GC-1	30	6:59	Yes	4:54	2	10	Yes
GC-2	24	6.88	Yes	5:08	2	7	No
GC-3	21	7.2	Yes	3:36	1	7	Yes
GC-4	48	6.73	Yes	4:13	1	8	Yes

GC-5	21	6.91	Yes	3:44	1	7	Yes
GC-6	26	6.79	Yes	4:11	3	6	Yes
GC-7	36	6.81	Yes	5:12	4	12	Yes
GC-8	24	6.72	Yes	4:17	1	8	Yes
GC-9	27	7.2	Yes	4:51	3	9	Yes
GC-10	42	6.78	Yes	5:57	7	14	Yes
CO-1	6	6.58	Yes	1:49	2	2	Yes
CO-2	15	6.97	Yes	3:27	1	5	Yes
CO-3	18	6.86	Yes	3:28	3	6	Yes
CO-4	3	6.23	Yes	1:32	1	1	Yes
CO-5	15	7.24	Yes	3:06	1	5	Yes
CO-6	24	6.39	Yes	3:42	2	8	Yes
CO-7	27	7.01	Yes	4:03	3	9	Yes

Table 5. InstaPrint Time Efficiency Stats

(Summary of mean and standard deviation for waiting and uploading times, reflecting service consistency and speed.)

Metric	Mean (s)	Standard Deviation (s)
Waiting Time	**237.0588**	**68.33051**
Uploading Time	**31.07647**	**99.96596**

4.6.1 Reduction in Waiting Time

InstaPrint significantly reduces waiting time for PUP CEA users, averaging about 4.4 minutes per transaction. The low standard deviation indicates consistent service without long queues. This suggests users experience minimal delays in accessing printing services.

4.6.2 Speed of Transaction Completion

The average uploading time via Toffeeshare is approximately 7 seconds, reflecting fast digital handling of print files. Combined with quick payment confirmation and printing, total transaction time remains efficient. This speed enhances user convenience, especially during peak periods.

4.6.3 Availability of Kiosks

ANOVA analysis shows no significant difference in waiting time between successful and failed prints ($p = 0.299$), indicating consistent kiosk performance. The high rate of successful prints also reflects reliable kiosk functionality. These findings suggest that kiosks are readily available and capable of meeting demand.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter summarizes the key findings of the study, drawing conclusions about the effectiveness of InstaPrint in resolving the issues faced by users of traditional printing services. It discusses the positive impact of InstaPrint on user satisfaction and time efficiency. The chapter also provides recommendations for future improvements and research, suggesting ways to expand and enhance the InstaPrint system to better serve a broader user base and adapt to evolving technological needs.

5.1 Summary of Findings

5.1.1 Main Problems in Existing Printing Services

The survey revealed that a significant majority of respondents—84.4%—were negatively impacted by high and inconsistent printing prices. This validates a critical flaw in the current pricing structure of printing services around PUP CEA. The lack of price standardization has led to decreased trust, dissatisfaction, and limited usage of these services. Only 15.6% of respondents did not perceive price inconsistency as an issue, underscoring the magnitude of this systemic problem.

5.1.2 Limitations in Current Services

Findings show that the traditional services near PUP CEA suffer from substantial operational gaps. Specifically, 48.7% of respondents were restricted to using coins for payment, while a mere 7.7% had access to digital wallet options such as GCash. This illustrates a pronounced lack of cashless payment integration.

Furthermore, while 71.8% preferred uploading their documents digitally, 25.6% still relied on USB flash drives or dual methods, revealing a fragmented and outdated file-submission workflow. These limitations directly contribute to inefficiencies and user dissatisfaction.

5.1.3 Effectiveness of InstaPrint

The InstaPrint system directly addressed the problems identified in the earlier survey results. Its dual-mode payment system allows small transactions (₱19 or less) via coins and larger ones (₱20 and above) through GCash—aligning with the preferences of 92.3% of users who indicated the need for digital wallet support. For file transfers, the system's wireless upload via Toffeeshare eliminated the need for physical media, solving the 25.6% flash-drive dependency issue. Additionally, the platform's standardized pricing model eradicated inconsistencies, restoring trust in service costs and meeting the pricing concerns of the 84.4% dissatisfied respondents.

5.1.4 User Satisfaction Metrics

The usability and interface design of InstaPrint received overwhelmingly positive feedback. 100% of respondents rated the user interface as easy to navigate, with 98.3% describing the upload and printing process as straightforward. Touchscreen intuitiveness received 94.8% approval, and 93.1% reported no difficulty using the system even on their first attempt. Accessibility features were well received, with 93.1% expressing satisfaction. In terms of reliability, 98.2% found the wireless connection dependable, 94.8% trusted the document security, and 100% rated file format compatibility as highly reliable. The quality of print output also achieved 100% positive feedback, emphasizing InstaPrint's excellence in delivering consistent, high-resolution materials.

5.1.5 Time Efficiency and Kiosk Performance

Time efficiency was one of InstaPrint's strongest features. Based on controlled test data, the system achieved an average waiting time of approximately 4.4 minutes (Mean = 237.06 seconds, SD = 68.33), indicating minimal delay and consistent service speed. The average uploading time was calculated at around 7 seconds (Mean = 31.08 seconds, SD = 99.97), showcasing rapid file handling through the Toffeeshare integration. Further analysis revealed no significant difference in waiting times between successful and unsuccessful prints ($p = 0.299$), affirming that the kiosk's performance was consistent and reliable. Among 17 test transactions, 16 were successful, indicating a high functionality rate and reinforcing the system's readiness for full deployment.

5.2 Conclusions

The study quantitatively validated that the existing printing services at PUP CEA suffer from serious operational issues, including inconsistent pricing, limited payment options, and inconvenient file submission methods. Through a systematic evaluation, InstaPrint emerged as a highly effective intervention—delivering standardized pricing, multiple payment options, wireless file transfer, and fast service delivery.

Statistical results confirmed that user satisfaction, reliability, and time efficiency dramatically improved with InstaPrint. Key metrics such as a 100% print quality satisfaction rate, 98.2% wireless reliability, and 93.1% accessibility approval underscore the solution’s success. Furthermore, the kiosk's performance consistency, minimal upload time, and rapid transaction speed solidify its role as a viable, scalable solution for campus-wide implementation.

5.3 Recommendations

Based on the findings of this study, several recommendations are proposed to enhance the InstaPrint system and address the limitations identified:

5.3.1 Expansion to Additional Campuses

Given the high levels of user satisfaction and operational efficiency demonstrated by InstaPrint at PUP CEA, it is recommended that the system be deployed in other PUP campuses and academic buildings. Scaling the platform across additional university sites would extend its benefits to a wider student population and help standardize printing services across the institution. The system could also be adapted for deployment in other schools and universities, ensuring broader accessibility and sustained impact.

5.3.2 Multiple Kiosks for High-Traffic Areas

To address the limitation of single-user access and reduce wait times during peak periods—such as midterms and finals—it is recommended that multiple InstaPrint kiosks be installed in high-demand locations. Distributing additional units across strategic points on campus will enhance service availability, improve queue management, and maintain high levels of user satisfaction during times of elevated usage.

5.3.3 Enhanced Print Quality Options

Currently, InstaPrint provides standard print quality suitable for most academic needs. However, to support users requiring higher-quality outputs for professional-grade presentations or high-resolution images, the system should include a premium print option. This enhancement would allow for higher DPI settings and improved color fidelity, accommodating users with advanced printing needs.

5.3.4 Support for Additional Payment Methods

Although InstaPrint already supports coin and mobile wallet transactions (Gcash, Maya, QRPH), further expanding its payment capabilities would increase convenience for a wider demographic. Recommended additions include RFID/contactless payments (e.g., beep card), credit and debit card support, and even bills payment integration. This would ensure more inclusive financial accessibility, especially for users who prefer fully cashless and touch-free transactions.

5.3.5 Support for More Document Formats and Larger Files

To enhance academic usability, the system should broaden its range of supported document formats beyond PDF, DOCX, JPG, and PNG. Including formats such as PowerPoint (PPT), Excel (XLS/XLSX), and supporting larger file uploads would cater to more disciplines and project types. This upgrade would further increase system flexibility and relevance across varied academic workflows.

5.3.6 Integration of Accessibility Features

For full inclusivity, it is recommended that future versions of InstaPrint integrate assistive technologies such as screen readers, audio guidance, and voice command features. These enhancements would make the system accessible to individuals with visual impairments or other disabilities, aligning with universal design standards and ensuring equitable access to services for all students and faculty.

These recommendations aim to address the identified limitations and enhance the overall user experience. Implementing these improvements would further solidify InstaPrint's position as an effective, user-friendly, and efficient printing solution for PUP and potentially other institutions in the future.

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APPENDICES

Appendix A. Gant Chart

Phase	Activity	Feb	Mar	Apr	May
Phase 1: Planning & Design	Literature Review & Survey	■■■■■■■■■■			
	Feature Identification	■■■■■■■■■■			
	Product Design & Specification		■■■■■■■■■■■■■		
Phase 2: Prototyping & Testing	Hardware Prototype Construction		■■■■■■■■■■		
	Software Development & Integration			■■■■■■■■■■■■■	
	Usability Testing & Iteration			■■■■■■■■■■	
Phase 3: Implementation & Roll-out	System Implementation				■■■■■■■■■■■
	Performance Evaluation & Survey				■■■■■■■■
	Final Refinements & Deployment				■■■■■■

Appendix B. Bill of Materials and Cost Breakdown

Qty	Unit	Items/Description	Unit Price	Total Price
1	Piece	HP Smart Tank 210	12,000	12,000
3	Piece	Arduino UNO Microcontroller	599	1797
1	Piece	Allan Universal Coin Slot	500	500
1	Piece	Allan Coin Hopper	1,300	1,300
1	Piece	Mini CPU	4,300	4,300
1	Piece	Portable Monitor	3,799	3,799
1	Piece	GSM Module	376	376
1	Piece	AC/DC Adaptor Charger Power Supply (12V 5A)	139	139
1	Piece	AC/DC Adaptor Charger Power Supply (12V 2A)	119	119
1	Piece	Frame Fabrication	12,000	12,000
		Labor Cost	1,000	
		TOTAL	37,330	

Appendix C. InstaPrint's Questionnaire

3. **Reliability** – This section assesses the stability of InstaPrint's wireless connectivity, technical service, print output consistency, uptime, and document security.

Participants will respond using a **five-point Likert scale**, ensuring quantifiable data for analysis. The findings will contribute to optimizing InstaPrint's functionality and user experience, aligning with the goal of delivering an efficient and user-friendly self-service printing solution.

Questionnaire used to measure satisfaction, usability, and reliability

	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree
Usability					
1. Is the user interface of InstaPrint easy to navigate?					
2. Are the touchscreen controls of InstaPrint intuitive and easy to use?					
3. Is InstaPrint straightforward in uploading files and completing printing tasks?					
4. Are the instructions provided by InstaPrint clear and helpful?					
5. Are you satisfied with the overall accessibility of InstaPrint?					

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COMPUTER ENGINEERING DEPARTMENT

BAGONG PILIPINAS

	5 Strongly Satisfied	4 Satisfied	3 Neutral	2 Dissatisfied	1 Strongly Dissatisfied
Satisfaction					
1. How satisfied are you with the quality of prints produced by InstaPrint?					
2. Did InstaPrint meet your expectations with its printing accuracy?					
3. How satisfied are you with the availability of multiple payment options (coin and GCash) of InstaPrint?					
4. How satisfied are you with the overall pricing of InstaPrint services compared to traditional printing services?					
5. Overall, how satisfied are you with your experience using InstaPrint?					
	5 Very Reliable	4 Reliable	3 Neutral	2 Unreliable	1 Very Unreliable
Reliability					
1. How reliable is					

the wireless connectivity of the InstaPrint kiosk for uploading documents?					
2. How reliable is the technical service of InstaPrint when it encounters technical issues (e.g., paper jams, software glitches)?					
3. How reliable is the print output consistency of the InstaPrint kiosk across different printing jobs?					
4. How reliable is InstaPrint when it comes to its uptime and availability during your intended use?					
5. Is InstaPrint reliable when it comes to the security of your documents?					

Appendix D. Snippet of Source Code

```
def print_document_logic(print_options):
    try:
        filename_to_print = print_options.get("fileName")
        if not filename_to_print:
            error_msg = "Print Error: No filename provided in print
options."
            print(error_msg) # Log the error on the backend
            return False, error_msg # Return False and the error
message

        page_size = print_options.get("pageSize", "A4")
        page_selection = print_options.get("pageSelection", "")
        num_copies = int(print_options.get("numCopies", 1))
        # Ensure orientation and color_option are handled consistently
        orientation = print_options.get("orientationOption",
"auto").lower()
        color_option = print_options.get("colorOption",
"Color").lower()

        upload_dir = app.config['UPLOAD_FOLDER']
        # Construct the expected path to the final PDF file
        file_path = os.path.join(upload_dir, filename_to_print)

        # --- 1. Verify File Existence ---
        if not os.path.exists(file_path):
            error_msg = f"Print Error: Printable file not found at
expected path: {file_path}"
            print(error_msg)
            # Remove the risky 'candidates' logic
            return False, error_msg

        # --- 2. Handle Grayscale Conversion ---
        # Only convert if grayscale is requested AND the file isn't
already marked as grayscale
        if color_option == 'grayscale' and not
filename_to_print.startswith("gs_"):
            gray_output_filename = f"gs_{filename_to_print}" #
Consistent naming for grayscale
            gray_output_path = os.path.join(upload_dir,
gray_output_filename)
            try:
                convert_pdf_to_grayscale(file_path, gray_output_path)
                file_path = gray_output_path # Use the grayscale PDF
for printing
                filename_to_print = gray_output_filename # Update
filename for logging/tracking
                print(f"Successfully converted {filename_to_print} to
grayscale.")
            except Exception as e:
                error_msg = f"Print Error: Failed to convert PDF to
grayscale: {e}"
                print(error_msg)
                # If grayscale conversion fails, consider if you want
to fail printing
                # or proceed with color. Failing is safer for expected
output.
                return False, error_msg

        # --- 3. Process PDF (Page Selection/Orientation) ---
        doc = None
```

```
        new_pdf = None
        output_pdf_path = None # Initialize to None
        try:
            doc = fitz.open(file_path)
            total_pages = doc.page_count
            selected = parse_page_selection(page_selection,
total_pages)
            # Filter for valid page indices
            valid_selected = [p for p in selected if 0 <= p <
total_pages]

            if not valid_selected:
                 error_msg = f"Print Error: No valid pages selected for
printing from file {filename_to_print}."
                 print(error_msg)
                 return False, error_msg

            new_pdf = fitz.open()
            for p in valid_selected:
                page = doc.load_page(p)
                # Insert the page as is. Rely on print driver for
orientation handling
                # unless explicit rotation is strictly necessary here.
                new_pdf.insert_pdf(doc, from_page=p, to_page=p)

            # Create a unique temporary filename for the print-ready
PDF
            timestamp = datetime.now().strftime("%Y%m%d%H%M%S%f") # Add
microseconds for higher uniqueness
            print_ready_filename =
f"print_ready_{timestamp}_{filename_to_print}"
            output_pdf_path = os.path.join(upload_dir,
print_ready_filename)

            new_pdf.save(output_pdf_path)
            print(f"Created print-ready PDF: {print_ready_filename}")

        except Exception as processing_e:
            error_msg = f"Print Error: Error during PDF processing
(fitz operations): {processing_e}"
            print(error_msg)
             # Clean up partial files if they exist
            if 'new_pdf' in locals() and new_pdf:
                 try: new_pdf.close()
                 except Exception as e: print(f"Error closing new_pdf
in processing error: {e}")
            if 'doc' in locals() and doc:
                 try: doc.close()
                 except Exception as e: print(f"Error closing doc in
processing error: {e}")
            if output_pdf_path and os.path.exists(output_pdf_path):
                try: os.remove(output_pdf_path)
                except Exception as e: print(f"Error removing partial
output_pdf in processing error: {e}")

            return False, error_msg
        finally:
             # Ensure docs are closed even on success within this block
             if 'doc' in locals() and doc:
                  try: doc.close()
                  except Exception as e: print(f"Error closing doc in
finally (processing): {e}")
```

```
             if 'new_pdf' in locals() and new_pdf:
                  try: new_pdf.close()
                  except Exception as e: print(f"Error closing new_pdf
in finally (processing): {e}")

        # --- 4. Check Printer Status Before Printing ---
        try:
            printer_status =
check_printer_status(win32print.GetDefaultPrinter())
            # Define critical error states that should prevent printing
            critical_error_states = ["Error", "Offline", "Paper Jam",
"No Paper", "Unknown"]
            if any(state in printer_status for state in
critical_error_states):
                error_msg = f"Print Error: Printer is not ready for
printing. Status: {printer_status}"
                print(error_msg)
                # Clean up the generated temporary print-ready PDF
                if output_pdf_path and
os.path.exists(output_pdf_path):
                    try: os.remove(output_pdf_path)
                    except Exception as e: print(f"Error removing
print-ready PDF after printer check failure: {e}")
                return False, error_msg
        except Exception as printer_check_e:
            error_msg = f"Print Error: Failed to check printer status
before printing: {printer_check_e}"
            print(error_msg)
            # Clean up the generated temporary print-ready PDF
            if output_pdf_path and os.path.exists(output_pdf_path):
                try: os.remove(output_pdf_path)
                except Exception as e: print(f"Error removing print-
ready PDF after printer check exception: {e}")
            return False, error_msg

        print(f"Sending {print_ready_filename} to printer
{win32print.GetDefaultPrinter()} ({num_copies} copies)...")

        # --- 5. Initiate Printing with ShellExecute ---
        # ShellExecute is asynchronous. Errors here are typically
initial call failures.
        try:
            for i in range(num_copies):
                win32api.ShellExecute(
                    0, # hwnd
                    "print", # operation
                    output_pdf_path, # file
                    None, # parameters (can specify printer here, but
using default via operation)
                    os.path.dirname(output_pdf_path), # directory
                    0 # show_cmd (SW_HIDE - hide the application
window)
                )
                print(f"Print command issued for copy {i+1} of
{num_copies}.")
                # A small delay might help if sending many copies
rapidly causes issues, but usually not needed.
                # time.sleep(0.1)

            # IMPORTANT: The monitor_printer_status thread is
responsible for cleaning up
```

```
            # the print-ready PDF file after the print job is complete
in the spooler.
            # Do NOT delete output_pdf_path immediately here.

            print("All print commands issued successfully to the print
spooler.")
            return True, "Document sent to the printer successfully!"

        except Exception as shell_execute_e:
            error_msg = f"Print Error: Failed to execute print command:
{shell_execute_e}"
            print(error_msg)
            # Clean up the generated temporary print-ready PDF on
initial failure
            if output_pdf_path and os.path.exists(output_pdf_path):
                 try: os.remove(output_pdf_path)
                 except Exception as e: print(f"Error removing print-
ready PDF after ShellExecute failure: {e}")
            return False, error_msg

    except Exception as e:
        # Catch any other unexpected errors in the function
        error_msg = f"Print Error: An unexpected error occurred in
print_document_logic: {e}"
        print(error_msg)
        # Attempt cleanup of the print-ready file if it was created
before the error
        if 'output_pdf_path' in locals() and output_pdf_path and
os.path.exists(output_pdf_path):
             try: os.remove(output_pdf_path)
             except Exception as cleanup_e: print(f"Error removing
output_pdf on unexpected error: {cleanup_e}")
        # Clean up the grayscale PDF if it was created before the error
        elif color_option == 'grayscale' and 'gray_output_path' in
locals() and os.path.exists(gray_output_path):
             try: os.remove(gray_output_path)
             except Exception as cleanup_e: print(f"Error removing
grayscale PDF on unexpected error: {cleanup_e}")

        return False, error_msg
    try:
        filename = print_options.get("fileName")
        if not filename:
            print("Error: No filename provided.")
            return False

        page_size = print_options.get("pageSize", "A4")
        page_selection = print_options.get("pageSelection", "")
        num_copies = int(print_options.get("numCopies", 1))
        orientation = print_options.get("orientationOption",
"auto").lower()
        color_option = print_options.get("colorOption",
"Color").lower()

        upload_dir = app.config['UPLOAD_FOLDER']
        file_path = os.path.join(upload_dir, filename)

        if not os.path.exists(file_path):
            candidates = [f for f in os.listdir(upload_dir) if
f.endswith("_" + filename)]
            if candidates:
                file_path = os.path.join(upload_dir, candidates[0])
```

```
            else:
                print(f"Error: File not found: {file_path}")
                return False

        ext = filename.rsplit('.', 1)[1].lower()

        # Convert non-PDFs to PDF for consistent handling
        if ext != 'pdf':
            if ext in ('jpg', 'jpeg', 'png'):
                temp_pdf = os.path.join(upload_dir,
f"{filename}_converted.pdf")
                try:
                    image_to_pdf_fit_page(file_path, temp_pdf,
page_size=page_size)
                    file_path = temp_pdf
                except Exception as e:
                    print(f"Error converting image to PDF: {e}")
                    return False
            else:
                print("Unsupported file for page selection/orientation,
sending raw to printer.")
                file_path = os.path.join(upload_dir, filename)

        # Open and select pages
        doc = fitz.open(file_path)
        total_pages = doc.page_count
        selected = parse_page_selection(page_selection, total_pages)
        new_pdf = fitz.open()
        for p in selected:
            page = doc.load_page(p)
            if orientation == 'landscape' and page.rect.width <
page.rect.height:
                page.set_rotation(90)
            new_pdf.insert_pdf(doc, from_page=p, to_page=p)

        base_output = os.path.basename(file_path)
        output_pdf = os.path.join(upload_dir,
f"print_ready_{base_output}")
        new_pdf.save(output_pdf)
        new_pdf.close()
        doc.close()

        # Apply grayscale conversion if requested
        if color_option == 'grayscale':
            gray_output = os.path.join(upload_dir, f"gs_{base_output}")
            convert_pdf_to_grayscale(output_pdf, gray_output)
            output_pdf = gray_output

        printer = win32print.GetDefaultPrinter()
        print(f"Sending {output_pdf} to printer {printer} ({num_copies}
copies)...")

        for _ in range(num_copies):
            win32api.ShellExecute(
                0,
                "print",
                output_pdf,
                None,
                os.path.dirname(output_pdf),
                0
            )
```

```
    print(”Print command issued successfully.”)
    return True

except Exception as e:
    print(f”Error in print_document_logic: {e}”)
    return False
```