My Print: Design and Development of A Microcontroller Based Smart Printing System

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Abstract
The demand for efficient, accessible, and secure printing services has significantly increased in academic institutions. Traditional printing shops face several operational challenges including long queues, outdated systems, and security concerns which cause inconvenience but also lead to inefficiencies. This study aimed to design and develop My-Print: Smart Printing System using a microcontroller to provide accessible, convenient, and automated printing services within a university campus. Specifically, it sought to identify the problems encountered by students and faculty in off-campus printing shops, define the technical design of the My-Print system, determine implementation considerations, and evaluate user acceptance based on the Technology Acceptance Model. The study utilized a developmental design guided by the ADDIE model and a quantitative approach to assess system usability and acceptance. The results revealed that the developed My-Print system integrates core functionalities such as file uploading, print customization, cashless payment, and administrative controls. The developed My-Print System provides accessible, convenient, and automated printing. Deployment analysis recommended 8 to 20 units across the entire campus. User evaluation yielded a grand mean of 3.56, interpreted as very satisfied, with statistically significant correlations among TAM variables. The results affirm the system's viability and acceptance within a large academic institution.

Keywords: Smart Printing System, System Deployment, Technology Acceptance Model

INTRODUCTION

Background of the Study

The demand for efficient, accessible, and secure printing services has significantly increased in academic institutions, particularly after the transition back to face-to-face learning post-COVID-19 (Zhu, 2022). Despite the digital transformation in education, the need for printed materials remains crucial for examinations, research papers, reports, and other academic requirements (Wang, 2023). However, traditional printing services in many schools, including those in Cebu, continue to face major challenges, such as long queues, outdated systems (Xu, 2012), and security concerns related to USB drives (Abeywardena, 2017). These issues not only cause inconvenience but also lead to inefficiencies that affect students' and faculty members’ productivity.

In the Philippines, particularly in Cebu, the demand for printing services has surged as schools and universities resume in-person classes. The scarcity of accessible printing options near schools often leads to logistical challenges for students, especially during peak academic periods. Implementing self-service printing kiosks can alleviate the burden on traditional printing service, allowing students to print documents efficiently without long waits (Panos, 2022).

One of the most pressing concerns in traditional printing services is the long waiting time due to high printing demand. As observed, students often experience delays because of inefficient queuing systems, printer malfunctions, and slow document processing (Sadjadee, 2018). Another critical issue is the continued reliance on USB drives for printing, which poses potential security and malware risks. USB devices are known to be a common vector for malware and viruses, which can compromise not only individual documents but also the entire printing system (Tischer et al., 2017). Additionally, handling shared USB drives increases the risk of virus transmission, a concern that became more pronounced during the COVID-19 pandemic (Pranggono & Arabo, 2021).

In light of this, the "My-Print: Design and Development of a Microcontroller Based Smart Printing System" project proposed an innovative solution to meet the high demand for printing in educational institutions. This smart printing system will provide decentralized, on-demand printing services by leveraging microcontroller technology specifically the Raspberry Pi. This project may provide an innovative approach to improving access to essential printing needs. By integrating microcontroller technology and accessibility, this project has the potential to transform printing services not only in Cebu but across the Philippines.

Review of Related Literature

Global and Local Demand for Printing in Academic Institutions

Despite the ongoing digital transformation in education, printed materials remain essential for various academic activities. Printed documents continue to play a vital role in examinations, research submissions, and administrative processes (Sundararajan, 2011). Their study emphasizes that, while digital media offer convenience, physical documents support deeper comprehension and serve as official records that are often required by academic institutions.

In the Philippines, the situation is similar. The demand for printing services has surged following the resumption of face-to-face classes after the COVID-19 pandemic (Tuga et al., 2022). In Cebu, where many schools and universities are located, printing facilities are often inadequate, resulting in overcrowded centers, long queues, and logistical challenges. Studies conducted a survey among university students and found that 75% of respondents experienced significant difficulty accessing printing services due to these issues. Such findings underscore the urgent need for modern, decentralized printing solutions that can accommodate high volumes while ensuring accessibility (Tuga et al., 2022).

Challenges in Traditional Printing Systems

Traditional printing systems in academic settings are fraught with several operational challenges that affect both efficiency and user satisfaction. Some studies identified key issues such as prolonged waiting times, frequent printer malfunctions, and inefficient document processing. These bottlenecks not only delay academic work but also lead to frustration among users, particularly during peak printing periods like exam seasons (Xu, 2012).

Security concerns further complicate traditional systems. Many institutions rely on USB flash drives for transferring documents to printing kiosks. However, studies demonstrated that USB drives are significant vectors for malware and viruses, posing severe security risks to both personal and institutional data (Tischer et al., 2017). Hygiene and cross-contamination issues associated with shared USB devices (Pierson & McCormack, 2016), a problem that gained heightened importance during the COVID-19 pandemic. Collectively, these challenges emphasize the need for a printing system that not only expedites the printing process but also mitigates security and health risks.

Microcontroller-Based Automation in Printing Systems

The incorporation of microcontroller-based automation has been identified as a promising solution to overcome the limitations of traditional printing systems. Studies had demonstrated that microcontrollers could effectively manage routine tasks—such as job scheduling, error detection, and real-time monitoring—thus reducing the need for manual intervention. Their work shows that automation enhances operational efficiency by streamlining processes and reducing human error (Bowling & Wojewoda, 2012).

A notable application of microcontroller-based automation is the use of the Raspberry Pi, a versatile embedded system that supports various peripheral integrations. Studies observed that the Raspberry Pi can function as the central controller in a smart printing system, managing print job queues and interfacing with networked printers (Hattori, 2009). In this context, researches explains that automation technologies like the Raspberry Pi allow for dynamic task allocation and efficient workflow management, which are crucial in environments with high and variable printing demands (Yaldaie et al., 2024)

Synthesis and Research Gap

The literature on printing in academic institutions reveals a persistent reliance on physical documents despite the growing prevalence of digital alternatives. Studies emphasize that printed materials remain indispensable for academic activities such as examinations, research papers, and official documentation. However, studies had highlight significant operational challenges within traditional printing systems, including long queues, inefficient document processing, and security vulnerabilities associated with USB-based document transfers.

Research on microcontroller-based automation, as demonstrated by (Yaldaie et al., 2024), shows considerable promise in addressing these inefficiencies by reducing manual intervention and streamlining printing workflows. Similarly, wireless printing technologies have been shown to mitigate security risks and improve user accessibility by enabling direct print job submissions from personal devices. Systems Integration Theory further reinforces the necessity of seamlessly uniting various hardware and software components to achieve reliable and scalable solutions (Chen et al., 2018).

Statement of the Problem

This study developed and implemented a My-Print: Smart Printing System using Raspberry Pi microcontroller that provides accessible, convenient, and automated printing solutions within the premises of University of Cebu - Lapu-Lapu and Mandaue. Specifically, it sought to answer the following questions:

1. What are the problems encountered by the students and faculty in the University of Cebu – Lapu-lapu and Mandaue when printing in print shops outside the university?
2. What are the optimal technical specifications and design elements for the My-Print: Smart Printing System, in terms of:

- technical functionalities
- design elements?
- What system prototype can be developed that integrates the following functionalities:
- a user-friendly application that enables users to access the system conveniently, upload documents, select print properties, and process payments
- an administrative interface that allows system administrators to manage user accounts, oversee printers and printing logs, and generate monitoring and sales reports?

3. What are the key aspects of implementing the My-Print Smart Printing system?
4. What is the level of user acceptance in conformity with the Technology Acceptance Model?

Significance of the Study

The primary beneficiaries are students from universities and schools in Cebu, particularly those studying at institutions such as the UC-LM campus. With a significant demand for printed materials for assignments, projects, and other academic requirements, students will benefit from the convenience of having easy, on-demand access to printing services. This will reduce the time spent searching for print shops and queuing for services, especially during peak academic periods like exams and project deadlines. Faculty members will benefit from faster access to printed educational materials, tests, handouts, and other resources required for class preparation and instruction. The smart printing machine will help reduce their workload in securing printed copies, allowing them to focus more on teaching and lesson planning. This improved efficiency will positively impact the teaching environment and educational quality.

School management and administrators will benefit from the improved operational efficiency that comes with having decentralized printing systems on campus. By offering on-site, smart printing solutions, schools can streamline their administrative processes, reducing their reliance on traditional print shops and cutting down costs associated with maintaining large-scale printing centers. Administrators can also offer this service as an added facility for students, improving the overall campus experience. The project will also indirectly benefit small business owners and entrepreneurs in the vicinity of universities and schools who rely on printing services. With the adoption of smart printing system, local print shop owners can adapt similar technologies or integrate their services with the system to stay competitive.

Scope and Limitations

This study focused on the design and development of My Print: Smart Printing System, an innovative printing solution that aimed to address the common printing challenges experienced by students, faculty, and staff within educational institutions. The system integrated a Raspberry Pi microcontroller, an RFID reader, a printer, and software components to create a seamless and automated printing experience. It was designed to allow users to upload documents wirelessly, authenticate their identity using RFID technology, and complete transactions with minimal manual intervention. The local setting of this study was the University of Cebu – Lapu-Lapu and Mandaue (UCLM) campus, where the prototype of the smart printing system was developed, tested, and evaluated. The system catered exclusively to the printing needs of students, faculty, and administrative staff within the UCLM community. This specific locale was chosen due to the increasing demand for efficient printing services within the campus and the accessibility of the site to the researchers.

Despite the potential of the smart printing system, this study acknowledged several limitations. The deployment of the system was restricted to the UCLM campus, and testing in other institutions or commercial establishments was beyond the scope of the research due to time, financial, and logistical constraints. Furthermore, the prototype was limited to providing basic printing functionalities, such as document uploading, printing, and payment. Advanced features were not included in this version of the system due to budgetary limitations and the defined scope of the study.

METHODOLOGY

Research Design

This study employed a developmental design, specifically utilizing the ADDIE model. Each phase builds upon the previous one, ensuring a logical flow of activities and alignment with the research objectives. This approach enables the research to deliver a user-centric and technically robust solution to address the growing demand for convenient printing services in Cebu's educational institutions. In addition, study utilized a quantitative-descriptive approach to collect and analyze numerical data on the performance and usability of the My-Print: Smart Printing System.

In the Analysis phase, the challenges faced by students, teachers, and the community related to printing needs were identified. Issues such as accessibility to print services, affordability, and convenience, particularly in schools and universities, were also considered. The researcher engaged with local print shop owners and IT staff to understand the technical feasibility and community impact.

The Design phase focused on creating technical blueprints for the system. The researcher created a blueprint for integrating a microcontroller-based system with hardware components. The software interface for document uploading, payment processing, and job tracking was designed. Wireframes and prototypes for the system's interface were developed to ensure ease of use for students and faculty. Core features such as document upload, status monitoring, and payment options were identified.

Development phase involved building the prototype. The researcher assembled and programmed the microcontroller to manage printing operations and connectivity. System applications for uploading documents, tracking print jobs, and managing payments were also developed.

The implementation phase focused on deploying the prototype in a real-world environment and monitoring its performance. The smart printing machine was installed in a designated area on the UCLM campus for a trial run. A sample group of students, faculty, and staff was allowed to use the system for their printing needs. A brief orientation was provided to users on how to operate the smart printing machine and its features. The researcher monitored usage patterns, user feedback, and system performance during the pilot phase.

The Evaluation phase tested the system's usefulness and ease of use under real-world conditions. The researcher analyzed how the system met the identified needs of the users and contributed to improving the operational efficiency of the campus.

Research Environment

The UCLM campus was strategically situated in the bustling areas of Lapu-Lapu City and Mandaue. It served as a vibrant hub that connected students, educators, and professionals from diverse backgrounds. The university was renowned for its commitment to academic excellence, innovation, and accessibility, making it a critical player in addressing the educational and technological needs of the region.

UCLM served as an ideal research environment for this study, given its dynamic academic community and its pivotal role in the educational landscape. The campus was home to a broad spectrum of programs catering to fields such as engineering, information technology, business, and maritime studies, among others. This diversity made it an excellent testing ground for a smart printing solution, as its population represented a wide array of printing needs, ranging from engineering blueprints to detailed business reports.

Given the large student population and the diversity of academic programs, the university was suitable to be the research environment for this study. It provided the necessary setting for the researcher to complete all phases of the project, including the implementation and evaluation phases.

Research Respondents

The selection of research respondents was a meticulous process designed to ensure a representative and inclusive sample that captured the diversity of stakeholders involved in the study. To guarantee representation across different user demographics, a stratified random sampling technique was employed. The research respondents of this study were composed of fifty individuals, which included students, faculty, administrators, and key stakeholders of the university.

Research Instrument

This study utilized a developmental approach, and during the evaluation phase of the system, a survey was conducted. The survey was answered and completed by key stakeholders and assessed the perceived ease of use, and perceived usefulness of the system. The questionnaire included an informed consent statement, which informed the respondents of the survey's purpose. The researcher prepared a two-part questionnaire to obtain the necessary data. The first part of the questionnaire gathered the demographic profile of the respondents. This section included information such as the respondent type, age, gender, and highest educational attainment. The second part of the questionnaire evaluated the system. To ensure the validity and dependability of the survey questionnaire, a pilot testing procedure was performed before data collection. This procedure consisted of a trial test of the survey questionnaire with a small sample of twenty participants who were not included in the final study.

Ethics and Data Gathering Procedure

The researcher followed a step-by-step process, beginning with the approval of the title, the acceptance of the adviser, and the submission of a formal request letter to the university. A transmittal letter was sent to the selected research environment to seek approval for conducting surveys with the target respondents, which included students, faculty, staff, and administrators. The researcher conducted pilot testing of the survey questionnaire to ensure its effectiveness in capturing relevant data on the challenges experienced by students and faculty. The research instrument was reviewed by the adviser to confirm the validity and appropriateness of the questions in relation to the study’s objectives.

Upon approval of the letters, the researcher administered the survey questionnaires to the respondents. A clear explanation of the study’s purpose, benefits, and significance was provided. The researcher prioritized obtaining permission and consent from the respondents before distributing the questionnaires, ensuring that participation was voluntary and responses were given sincerely. The surveys were conducted face-to-face to promote accountability and accuracy in responses. After achieving the required number of respondents, the researcher collected all completed questionnaires and verified the accuracy and completeness of the responses. Finally, all the data gathered were analyzed, interpreted, and tabulated to draw meaningful insights and findings.

The research was conducted with strict adherence to ethical standards. Before data collection, informed consent was obtained from all participants, who were made aware of the study's nature, purpose, and rights. Participants were assured that their personal information would remain confidential and that their responses would be anonymous. Any personal data collected during the study was kept confidential and used solely for research purposes. The study complied with all relevant ethical guidelines and regulations.

RESULTS AND DISCUSSION

Analysis of Problems encountered in Traditional Printing Services

To systematically identify the factors contributing to the inefficiencies in traditional printing systems in academic settings, the researcher conducted an initial survey. A root cause analysis using a fishbone diagram found in Figure 1 was employed. The diagram categorized the problems into six key domains: Materials, Methods, Machine, Measurement, Environment, and People. Each of these domains encompasses specific issues that collectively presented common concerns in printing services. The varying font sizes within the diagram further illustrate the frequency of occurrence, with larger text indicating more prevalent problems and smaller text signifying less frequent but still relevant issues.

In terms of Materials, the most common challenges is the reliance on outdated USB drives, which significantly increases the risk of malware and virus transmission within the printing environment. These outdated storage devices are often used across multiple, unsecured computers, making them a common vector for spreading malicious software.

The Methods category highlights the traditional, manual queuing process as a significant source of inefficiency. This outdated approach results in long waiting times, especially during peak hours, and creates unnecessary congestion in print shops.

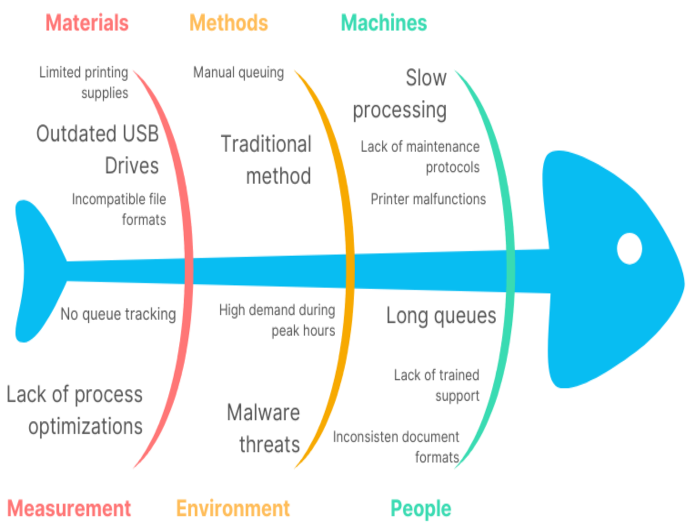
Under Machines, slow processing caused by outdated equipment and lack of maintenance protocols is a major recurring problem. These technical limitations often result in printer malfunctions, contributing to system downtime and long service interruptions.

The People factor emphasizes the issue of long queues, largely driven by human resource limitations and ineffective system management. The lack of trained personnel to provide technical support means that minor printer issues or user errors often escalate into significant delays.

The Environment also plays a critical role, with high demand during peak hours being a well-documented challenge. The current infrastructure is unable to accommodate the surge in printing requests, especially during examination periods or project deadlines.

Lastly, Measurement or process optimization deficiencies present a fundamental obstacle to efficient printing services. The absence of queue tracking systems and real-time monitoring prevents users from being informed about their position in the queue or the status of their print jobs.

Figure 1: Fishbone Diagram

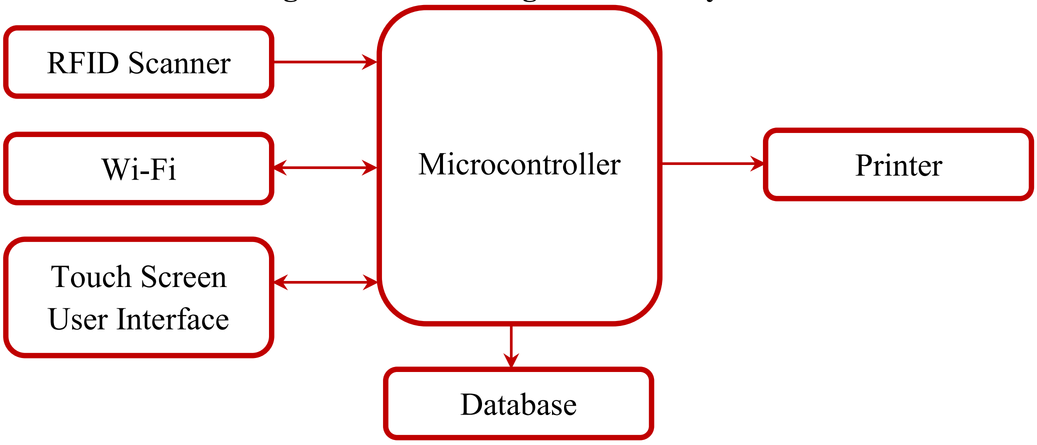


Designs and Features of the My-Print System

Block Diagram of the System

The block diagram in Figure 2 illustrates the system's block diagram showcasing how the different components interact to provide seamless, and user-friendly printing services. Each component in the diagram serves a critical role in ensuring the system functionality and efficiency.

Figure 2: Block Diagram of the System



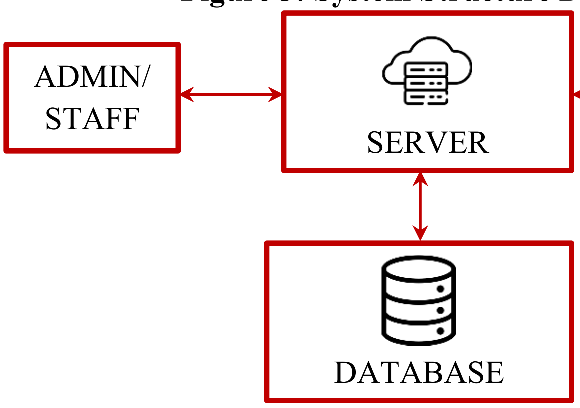
The core of the system is the Raspberry Pi Microcontroller, which acts as the main processing unit. It manages communication between the different components, processes user input, validates transactions, and sends print commands to the printer. The RFID Scanner is responsible for verifying user identity and processing payment transactions. Users will scan their RFID cards to log into the system and access printing services. The RFID provides the system with secure user authentication where only registered users with valid RFID credentials can access the printing services.

The Touch Screen User Interface serves as the primary method for users to interact with the printing system. Through this interface, users can: navigate system features, manage print transactions and monitor print status. The printer is the output device responsible for generating physical copies of the submitted digital documents. The system accepts files via local network or Wi-Fi enables the system to accept document files wirelessly. The database is essential for storing and managing all system-related data.

System Structure Diagram

The diagram in Figure 3, provides the System Structure Diagram, which provides the flow of data and interactions between its key elements. The system is designed to allow smooth communication and efficient functionality of the system while maintaining resilient management system.

Figure 3: System Structure Diagram



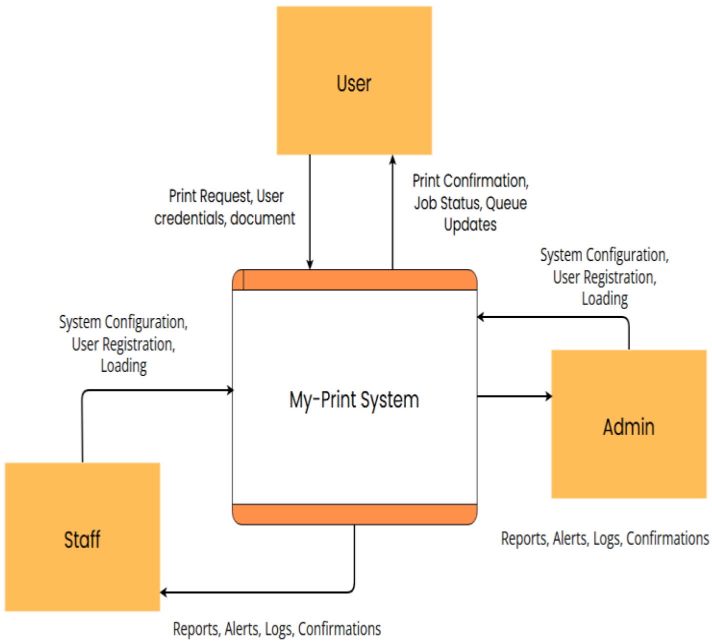
The admin serves as the primary authority for managing the system. The staff access provides operational management of the accounts, monitoring and troubleshooting any issues. The server acts as the central hub of the system, which communicates with all the components. The Mi-print system represents the smart printing system which the users interact to complete their printing task.

Data Flow Diagram

Figure 4 shows the data flow diagram of the system. The Level 0 Data Flow Diagram (DFD) provides a contextual overview of the My-Print System, outlining the interaction between external entities and the main process that governs the smart printing operations. This diagram represents the entire system as a single process and depicts how data flows in and out of the overall system.

At the core of the diagram is the My-Print System, which is responsible for managing all interactions related to print requests, user authentication, system configurations, and administrative operations. This central process receives data inputs from users, staff, and administrators and returns relevant outputs such as confirmations, status updates, and system reports.

Figure 4: Dataflow Diagram

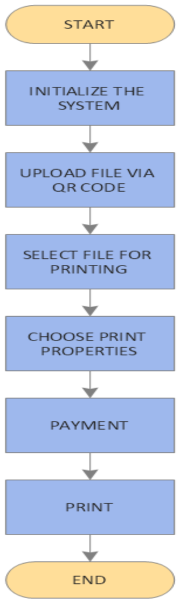


The user, typically a student or faculty member, interacts directly with the system by submitting print requests, credentials, and document files for printing. The system, in turn, provides feedback in the form of print confirmations and information. The staff contribute to the operation of the system, often assisting with the users, daily maintenance and technical support. The administrator plays a critical role in system governance. Through the DFD, the admin sends configuration data, user registration details, and system-loading instructions to the My-Print System. In return, the system can provide comprehensive reports, logs, and confirmation messages.

Program Flowchart

Figure 5 shows the flowchart of the user side of the My-Print System to illustrate the sequence of steps and the flow of control or information. It helps in understanding how a particular process works by breaking it down into manageable, logical steps.

Figure 5: Program Flowchart



The program flowchart illustrates the step-by-step sequence of operations that occur within the user side of the system. From uploading a file and setting print preferences then to payment, validation and printing.

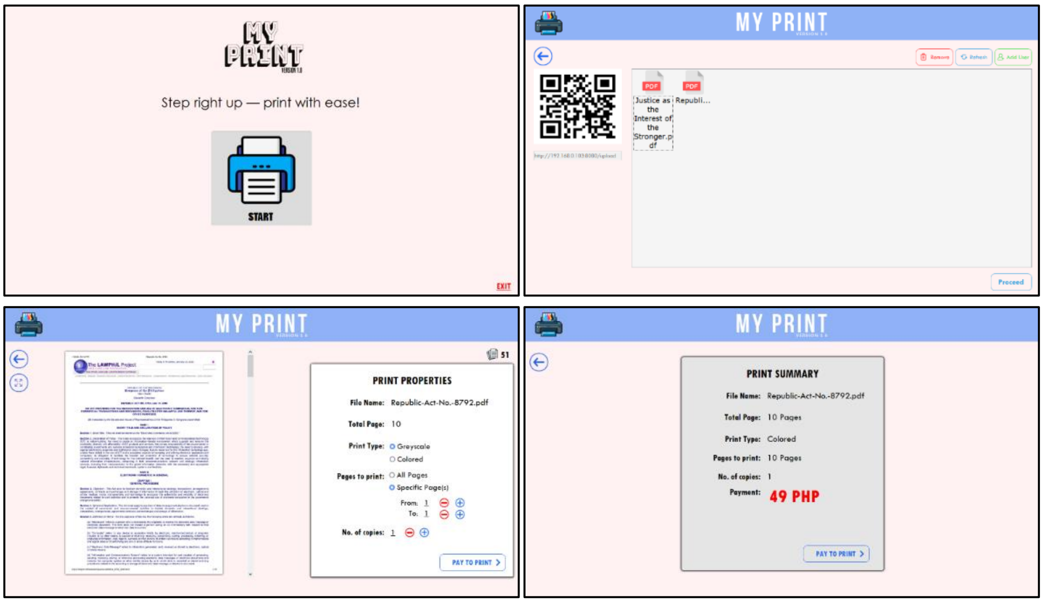
Development of the System

The development phase is the stage where the actual creation of the system takes place, based on the plans and specifications established during the Design Phase. It serves as the bridge between conceptual planning and tangible output, transforming theoretical blueprints into functional prototypes and operational components. In this phase, all necessary hardware, software, and technical elements of the project are constructed, assembled, tested, and refined to ensure that the system meets the defined requirements and user expectations.

The development phase involved the collaborative effort of researcher, technical experts, and project stakeholders to build both the hardware and software components of the smart printing machine. The hardware aspect included the integration of the Raspberry Pi microcontroller, which served as the central processing unit of the system. Other essential hardware components such as printers, payment modules, and network interfaces were also assembled to ensure the system's functionality in a real-world environment.

Figure 6 shows the graphical user interfaces of the system at the user side. This interface guides users through printing, from uploading files and selecting print preferences to processing payments and confirming transactions. Users will need to click on the start button at the center of the interface to begin using the system. This interface provides a QR code for which the users can upload the file. Users can scan the QR code and send the files for printing. Uploaded file will reflect in the file box. Users can select files and click on the proceed button to continue with the printing process.

Figure 6: Graphical User Interface of the System

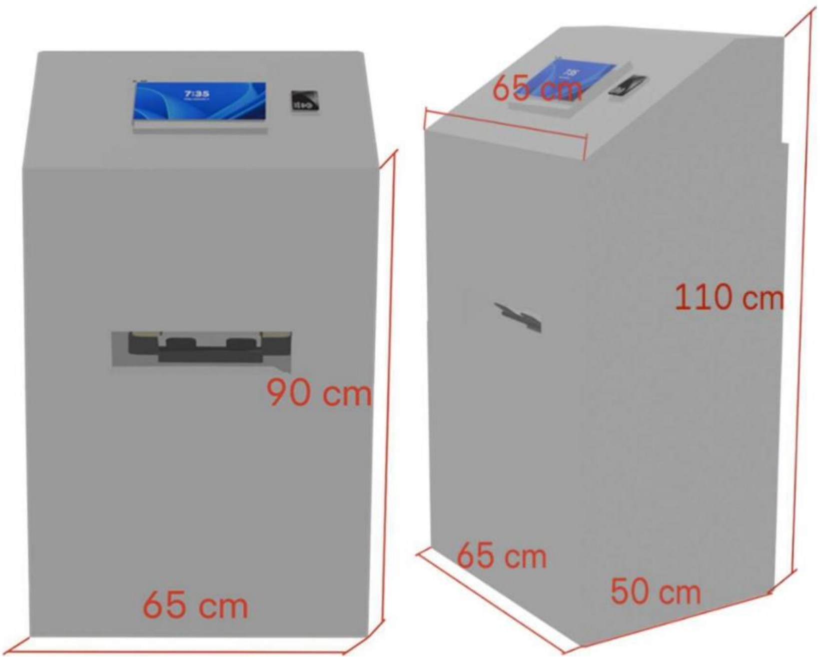


The print properties allow the user to check the file name of the document to be printed. It also shows the number of pages of the selected file. User can select the printing properties by selected the print type, whether it is colored printing or grayscale. It also provides the option to select which pages to print and the number of copies. The left side of the user interface provides a file preview which allows the user to check on the contents of the file and select the appropriate pages to be printed.

Prototype of the System

Figure 7 shows the visual layout of the prototype which integrates essential components into a compact, user-friendly kiosk suitable for campus environments.

Figure 7: Prototype of the System



It features a touchscreen interface, allowing users to upload files, choose print settings, and confirm transactions. The Epson L121 printer is securely housed within the system, delivering printed outputs in color or grayscale. An RFID scanner enables quick, cashless payments using student ID cards. The layout is designed for user accessibility and technician maintenance, ensuring secure, efficient, and continuous operation.

KEY ASPECTS OF IMPLEMENTING THE SYSTEM

Number of systems that can be deployed

With an estimated 6,000 to 10,000 students who may regularly require printing services, a distributed deployment of printing machines becomes essential. A common ratio for efficient service is approximately one machine per 500 to 800 students. Based on this, around 8 to 12 units would be suitable for 6,000 students, while a population of 10,000 students would require approximately 13 to 20 units.

Strategically, this system should be placed in accessible locations such as the library, student centers, spaces near the offices, and main lobbies. High-traffic areas may require multiple units, especially during peak hours such as class breaks or major submission periods.

Technical Requirements for Deployment

The system application can be deployed and accessed through the Raspberry Pi microcontroller. The system must include the following components: Raspberry Pi microcontroller, an EPSON L121 printer, USB type NFC RFID reader/writer, touch screen monitor. To create and run the needed software of both the user and admin, the Visual Studio will be installed along with its requirement of Microsoft framework. MySQL was used to create the system database. A Server.py python script will be needed for the kiosk to received files. The user kiosk and admin device must be connected to the same network.

LEVEL OF USER ACCEPTANCE OF THE SYSTEM

This section explores the level of user acceptance and satisfaction with the system based on the principles of the Technology Acceptance Model (TAM). By examining key factors such as Perceived Usefulness, and Perceived Ease of Use, the researcher assessed how users interact with the system and how these elements influenced their overall satisfaction.

Table 1 shows the level of user acceptance and satisfaction with the system in terms of Perceived Usefulness (PU). Perceived Usefulness is defined as the degree to which a person believes that using a particular system or technology will improve their job performance. The more useful a user finds the system, the more likely they are to adopt it.

Table 1: Level of User Acceptance in terms of PU

Perceived Usefulness (PU)	Mean	SD	VI	QD
1. Using the smart printing machine will enhance my efficiency in completing printing tasks.	3.58	0.57	VS	HA
2. The smart printing machine will save time compared to traditional printing services.	3.34	0.66	VS	HA

3. The system provides the flexibility to print documents on demand without delays.	3.52	0.61	VS	HA
4. The availability of wireless printing will make the printing process more convenient.	3.66	0.48	VS	HA
5. I believe this system will be a useful tool for my academic or professional needs.	3.52	0.54	VS	HA
Aggregate Mean	**3.52**		**VS**	**HA**

The data reveal that the aggregate mean for Perceived Usefulness is 3.52, interpreted as Very Satisfied (VS), with a standard deviation that ranges from 0.48 to 0.66 which corresponds to a Highly Acceptable (HA) level of user acceptance.

Among the indicators, the statement "The availability of wireless printing will make the printing process more convenient" obtained the highest mean of 3.66, indicating that wireless printing is a highly appreciated feature among users. Meanwhile, the statement "The smart printing machine will save time compared to traditional printing services" had the lowest mean of 3.34, which, although still interpreted as Very Satisfied, suggests that few users may still have reservations regarding the system's time efficiency compared to traditional methods. These results indicate that users perceive the system as a useful tool for enhancing efficiency, flexibility, and convenience in accomplishing their printing tasks within the university setting.

Table 2 shows the level of user acceptance and satisfaction with the system in terms of Perceived Ease of Use (PEOU). Perceived Ease of Use refers to the extent to which a person believes that using the system will be free of physical or mental effort. If a technology is easy to learn and operate, users are more likely to feel comfortable using it, which increases their acceptance.

Table 2: Level of User Acceptance in terms of PEOU

Perceived Ease of Use (PEOU)	Mean	SD	VI	QD
6. The interface of the smart printing machine is user-friendly and easy to navigate.	3.52	0.58	VS	HA
7. Learning how to use the system will require little effort.	3.58	0.50	VS	HA
8. I believe the instructions for operating the system are clear and understandable.	3.40	0.70	VS	HA
9. I find it easy to upload documents and complete the printing process using the machine.	3.34	0.72	VS	HA
10. Troubleshooting or resolving issues with the system will be straightforward.	3.52	0.68	VS	HA
Aggregate Mean	**3.47**		**VS**	**HA**

The results for Perceived Ease of Use show an aggregate mean of 3.47, interpreted as Very Satisfied (VS) with a Highly Acceptable (HA) level of user acceptance. The standard deviation values ranged from 0.50 to 0.72, indicating a moderately consistent perception among respondents. These results highlight that the smart printing machine is generally regarded as user-friendly, easy to navigate, and accessible, which contributes significantly to its acceptability and adoption among users.

CONCLUSION

Based on the findings of the study, it can be concluded that traditional printing services outside the university remain inefficient and inconvenient for students and faculty due to recurring operational challenges such as outdated equipment, manual queuing, limited human resources, lack of maintenance protocols, and the absence of real-time monitoring and queue management.

The My-Print: Smart Printing System successfully addresses the identified inefficiencies by providing a user-friendly, automated, and secure printing service within the university. It was designed with integrated features, including a Raspberry Pi microcontroller, RFID authentication, touchscreen interface, wireless connectivity, and centralized database management, promote ease of use, efficiency, and data security for users.

The system offers essential functionalities that enhance accessibility and operational management. These include a user application that allows file uploads, print property selection, and integrated payment, as well as an administrative interface for managing user accounts, monitoring print logs, and generating sales reports, which collectively improve system oversight and service delivery.

The overall level of user acceptance with the system was found to be highly acceptable, as validated by the Technology Acceptance Model (TAM). Users perceived the system as useful, easy to operate, and expressed favorable attitudes and intentions to adopt the system for future printing needs.

RECOMMENDATIONS

In light with the findings and conclusions of the study, the following recommendations are offered:

Further Research. It is recommended that further research and analysis of the system to be conducted from the development and improvement of the software, the improvement in the ergonomic design of the kiosk, and more advance system functionalities.

Adoption of the Design. It is recommended that the University of Cebu Lapu-lapu and Mandaue, adopt this design approach and deploy this system for the students, faculty, and staff. It is suggested that they adopt this system to eliminate common problems experienced in traditional printing shops.

Utilization of the Project. Students are encouraged to fully utilize the My-Print system for efficient printing especially on peak academic periods; more instructional guides and multilingual support should be provided for better usability.

Business Installation. Businesses are recommended to install more units in strategic locations especially in high-traffic areas, add alternative payment options such as mobile e-wallets, and regularly evaluate system and conduct evaluations performance for future expansion.

Further Studies. It is also recommended that an improved system utilizing cloud-based uploading, machine learning and artificial intelligence be further studied to further improve user experience and system impact.

REFERENCES

1. Abeywardena, I. S. (2017). Print2Screen Mobile App: Embedding Multimedia in Printed ODL Course Materials Using QR Codes. 4(3), 366–374. https://files.eric.ed.gov/fulltext/EJ1161785.pdf
2. Chen, D., Huang, S., Chen, H., Xie, Y., & Zhu, Q. (2018). Self-service printing system under Raspberry Pi.
3. Hattori, H. (2009). Controller for printing device. https://patents.google.com/patent/US8451469B2/en
4. Panos, M. (2022). Smart Self-Service Transcripts and Certificates Printing System Supporting Campus Services and Epidemic Prevention. https://doi.org/10.1109/apct55107.2022.00015
5. Pranggono, B., & Arabo, A. (2021). COVID-19 Pandemic Cybersecurity Issues. 4(2). https://doi.org/10.1002/ITL2.247
6. Pierson, C., & McCormack, A. (2016). USB drive security systems and methods. https://patents.google.com/patent/US9582445B1/en
7. Sadjadee, S. (2018). Reducing students' waiting time for assistance in programming laboratory sessions by using electronic queueing. Integrating Technology into Computer Science Education, 358–359. https://doi.org/10.1145/3197091.3205837
8. Sundararajan, S. G. (2011). Printed Books and E- Books Utilization Among the Professional College Students: A Study. Indian Journal of Applied Research, 3(4), 216–217. https://doi.org/10.15373/2249555X/APR2013/71
9. Tischer, M., Durumeric, Z., Bursztein, E., & Bailey, M. (2017). The Danger of USB Drives. 15(2), 62–69. https://doi.org/10.1109/MSP.2017.41
10. Tuga, B., Jocson, J., & Mabunga, R. A. (2022). The impact of COVID-19 on a Philippine university: Challenges and responses towards a new normal in education. https://doi.org/10.56278/asten.vi.1777
11. Wang, J. (n.d.). The Application and Impact of Digital Printing Technology in Higher Education Teaching. Advances in Educational Technology and Psychology. https://doi.org/10.23977/aetp.2023.071618
12. Xu, Q. (2012). Research on improved self-service printing and photocopying system in campus. Journal of Zhejiang University of Science and Technology. https://en.cnki.com.cn/Article_en/CJFDTOTAL-YYGC201201013.htm
13. Yaldaie, A., Porras, J., & Drögehorn, O. (2024). Innovative Home Automation with Raspberry Pi: A Comprehensive Approach to Managing Smart Devices. Asian Journal of Computer Science and Technology, 13(1), 27–40. https://doi.org/10.70112/ajcst-2024.13.1.4260
14. Zhu, Y. (2022). Smart Self-Service Transcripts and Certificates Printing System Supporting Campus Services and Epidemic Prevention. 36–40. https://doi.org/10.1109/APCT55107.2022.00015