Development of an Internet of Things Based Printer Vending Machine

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Abstract— Many computer stores close in the wake of the COVID 19 pandemic. The predicament of people without printer machines is impacted by this. Customers must travel quite a distance to reach printing businesses due to their problematic locations. Furthermore, printer operators are required to remain on standby to oversee computer and printer operations, handle payments, and maintain a record of sales throughout the entire day. To address the current manual issue in printing services, this study set out to create a machine that is function independently, operate autonomously, and require coins for operation utilizing Arduino. It is made with the intention of making the printing operator's job easier and the user as well.

The project was tested, and the respondents were twelve three (3) IT experts, five (5) printing services business owners and seven (7) casual users. The researchers used the International Organization for Standardization (ISO) 25010 for the evaluation of software in terms of its functional suitability, performance efficiency, compatibility, usability, reliability, security, and maintainability. The mean was used to analyze and interpret the data. All means in each characteristic were interpreted as "Very Useful". The result proved that the Development of an Internet of Things based Printer Vending Machine, a system has a Very Useful operations and functions.

Keywords— Printer, Vending Machine.

I. INTRODUCTION

A coin-operated vending machine is a type of vending machine that requires customers to insert coins in order to make a purchase. These machines have been widely for decades and are still commonly found in various locations.

A coin-operated vending machine is a type of vending machine that requires customers to insert coins in order to make a purchase. These machines have been widely used for decades and are still commonly found in various locations [1]. The current reloading services where the retailer inputs both the number and amount specified by the customer, the customer then checks the number and amount inputted by the retailer [2]. Its purpose is to present the design and implementation of a novel vending machine concept based on desktop-scale extrusion additive manufacturing (AM). Due to cost, access to AM technologies at academic institutions tends to be limited to upper-level courses to support project-based coursework. However, with the decreasing cost of desktop-scale AM technology, there is potential to improve student access to such technologies and provide more opportunities for AM education [3].

The overall level of usability of the designed software interface is very high in view of the fact that almost all of the system features and functions are evident with the best quality characteristics in architectural design, very simple and usable [4].

In connection with this, the researchers would like to propose and develop a printer vending machine that will lessen the manual issue in printing services. This machine will be functioning independently, operating autonomously, and requiring coins for operation. It will be made to make the printer operator's / administrator job easier as well as the user.

II. METHODOLOGY

The selection of adequate concepts and efficient tools is imperative in the Development of an Internet of Things based Printer Vending Machine. Thus, the following are the essential concepts that contribute to the development and implementation.
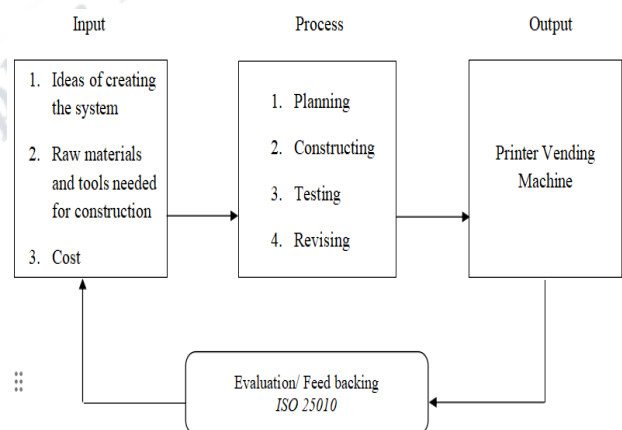
Figure 1. Conceptual Framework of Development of an Internet of Things based Printer Vending Machine

Figure 1 shows how the Development started; the researchers experienced how resource consuming it is to manage a printing services business also to the customers who needed those services. The researchers interviewed printing services business owners and customers about the problems they encounter.

Before the Printer Vending Machine was implemented, some experts and future users tested and evaluated this system. Whenever an undesired result notifies, a feedback mechanism is incorporated.

Project Description

Printer Vending Machine would be used for printing documents. This system will help the operator by minimizing their tasks in operating the printing machine. This will also provide users a convenient way of printing their documents.

Procedures

In this study the software and hardware development model that will be used is the Waterfall Model of Software Development Life Cycle (SDLC). The Waterfall model is the earliest SDLC approach that was used for software development. The Waterfall Model illustrates the software development process in a linear sequential flow. This means that any phase in the development process begins only if the previous phase is complete.

Planning

The First stage in this system development was planning. The proponent identified and specified how the printing system works. The researchers also analyzed the data gathered and found out that the Coin Operated Printing Machine is more convenient to the users in terms of printing their documents.

Software and Hardware Analysis and Design

The identification of data utilized by the system was done in the second stage. Identified the most typical criteria for the printing vending machine, planned how to implement the system, and developed software that could satisfy the needs of the users. The suggested system's architecture and design were then planned.

Software and Hardware development and Coding

The system application required for the user's interaction was planned and developed during this phase. It must be appropriate to execute a program for the suggested system. It made use of Sublime Text 3, Python, Qt Designer, SQLite Studio, LibreOffice, Twilio, and SMTP2GO.

Prototyping

Making a prototype is the third step. Create the hardware circuit, and then program the Arduino to interact with it.

Testing

The most crucial stage of system development is the next one, where the developed system is being evaluated for potential improvements. Additionally, it seeks to find flaws and enhance system performance. The system's proponent created the functional flaw to raise the bar for the new system.

Deployment and Maintenance

The final phase is implementation. Users will utilize the system after testing to evaluate its usability and functionality. The person who developed the system should be responsible for maintaining the software. The functioning of the program should be maintained by performing updates as necessary.

III. RESULTS AND DISCUSSION

The system was evaluated based on software quality standards to test its conformance in terms of its functional suitability, performance efficiency, usability, reliability, security and maintainability. Respondents' evaluators are the three (3) IT experts, five (5) printing services business owners and seven (7) user respondents.

Table 1. The Functional Suitability Evaluation Result of the Respondents

Functionality Suitability	IT Experts		Printing Services Business Owners		Casual Users		Grand Total Mean	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
Functional Completeness • The system covers all the specified tasks and user objectives.	4.55	Very Useful	4.64	Very Useful	4.46	Very Useful	4.55	Very Useful
Functional Correctness • The system provides the correct results with the needed degree or precision	4.60	Very Useful	4.35	Very Useful	4.38	Very Useful	4.44	Very Useful
Functional Appropriateness • It facilitates the accomplishment of specified tasks and objectives.	4.75	Very Useful	4.80	Extremely Useful	4.60	Very Useful	4.72	Very Useful
Grand Mean	**4.63**	Very	**4.60**	Very	4.48	Very	**4.57**	Very

Table 1 shows the functional suitability of the Printer Vending Machine. Based on the evaluation of the respondents, a system has a "Very Useful" functional suitability.

Table 2. The Performance Efficiency Evaluation Result of the Respondents

Performance Efficiency	IT Experts		Printing Services Business Owners		Casual Users		Grand Total Mean	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
Time Behaviour • The system response and processing times and throughput rates when performing its functions, meet requirements.	4.65	Very Useful	4.60	Very Useful	4.55	Very Useful	4.60	Very Useful
Resource Utilization • The system amounts and types of resources used when performing its functions, meet requirements.	4.60	Very Useful	4.40	Very Useful	4.35	Very Useful	4.45	Very Useful
Capacity • The system maximum limits of parameter meet requirements.	4.75	Very Useful	4.80	Extremely Useful	4.70	Very Useful	4.75	Very Useful
Grand Mean	**4.67**	**Very Useful**	**4.60**	**Very Useful**	4.53	Very Useful	**4.60**	**Very Useful**

Table 2 shows that based on the evaluation of the respondents, a system has "Very Useful" in terms of performance efficiency.

Table 3. The Compatibility Evaluation Result of the Respondents

Compatibility	IT Experts		Printing Services Business Owners		Casual Users		Grand Total Mean	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
Co-existence • The system can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product.	4.65	Very Useful	4.70	Very Useful	4.80	Very Useful	4.72	Very Useful
Resource Utilization • The system amounts and types of resources used when performing its functions, meet requirements.	4.60	Very Useful	4.80	Very Useful	4.70	Very Useful	4.70	Very Useful
Grand Mean	**4.63**	**Very Useful**	**4.75**	**Very Useful**	**4.75**	**Very Useful**	**4.71**	**Very Useful**

Based on the Table 3 result, the Printer Vending Machine was confirmed by the IT Experts who "Strongly Agree" with the "Co-existence" (M= 4.65) and "Interoperability" (M= 4.60) with a total count of 4.63.

Table 4. The Usability Evaluation Result of the Respondents

Usability	IT Experts		Printing Services Business Owners		Casual Users		Grand Total Mean	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
Appropriateness Recognizability • The system allows users to recognize if it is appropriate for their needs	4.65	Very Useful	4.70	Very Useful	4.80	Very Useful	4.72	Very Useful
Learnability • The system can be used by specified users to achieve specified goals of learning to use the application with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use	4.60	Very Useful	4.80	Very Useful	4.70	Very Useful	4.70	Very Useful
Operability • The system has attributes that make it easy to operate and control	4.60	Very Useful	4.80	Very Useful	4.70	Very Useful	4.70	Very Useful
User Error Protection • The system protects user against making errors	4.60	Very Useful	4.80	Very Useful	4.70	Very Useful	4.70	Very Useful
User Interaction Aesthetics • The user interface enables pleasing and satisfying interaction for the user	4.60	Very Useful	4.80	Very Useful	4.70	Very Useful	4.70	Very Useful
Accessibility • It can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use	4.60	Very Useful	4.80	Very Useful	4.70	Very Useful	4.70	Very Useful
Grand Mean	**4.63**	**Very Useful**	**4.75**	**Very Useful**	**4.75**	**Very Useful**	**4.71**	**Very Useful**

The results based on the Table 4, the evaluation of Printer Vending Machine has a "Very Useful" usability characteristics.

Table 5. The Reliability Evaluation Result of the Respondents

Reliability	IT Experts		Printing Services Business Owners		Casual Users		Grand Total Mean	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
Maturity • The system meets the needs for reliability under normal operation	4.45	Very Useful	4.55	Very Useful	4.60	Very Useful	4.53	Very Useful
Availability • It is operational and accessible when required for use.	4.70	Very Useful	4.75	Very Useful	4.70	Very Useful	4.72	Very Useful
Fault Tolerance • It operates as intended despite the presence of hardware or software faults.	4.55	Very Useful	4.60	Very Useful	4.65	Very Useful	4.60	Very Useful
Recoverability • The system can recover the data directly affected and re-establish the desired state.	4.45	Very Useful	4.55	Very Useful	4.50	Very Useful	4.50	Very Useful
Grand Mean	**4.54**	**Very Useful**	**4.61**	**Very Useful**	**4.61**	**Very Useful**	**4.59**	**Very Useful**

As shown in Table 5, the system has an outstanding software reliability as confirmed by the IT Experts as evaluators who "Strongly Agree" with the "Maturity" (M= 4.45), "Availability" (M= 4.70), "Fault Tolerance" (M= 4.55), and "Recoverability" (M= 4.45) with a total mean of 4.54.

Table 6. The Security Evaluation Result of the Respondents

Security	IT Experts		Printing Services Business Owners		Casual Users		Grand Total Mean	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
Confidentiality • The system ensures that data are accessible only to those authorized to have access.	4.85	Very Useful	4.80	Very Useful	4.75	Very Useful	4.80	Very Useful
Integrity • The system prevents unauthorized access to, or modification of, computer programs or data.	4.75	Very Useful	4.70	Very Useful	4.80	Very Useful	4.75	Very Useful
Non-repudiation • It can be proven to have taken place, so that the events or actions cannot be repudiated later.	4.70	Very Useful	4.65	Very Useful	4.70	Very Useful	4.68	Very Useful
Grand Mean	**4.77**	**Very Useful**	**4.72**	**Very Useful**	**4.75**	**Very Useful**	**4.74**	**Very Useful**

Table 6 shows the result, that in terms of security of the system was evaluated as "Very Useful" confirmed by the IT Experts who "Strongly Agree" with the "Confidentiality"

(M= 4.85), "Integrity" (M= 4.75), and "Non-repudiation" (M= 4.70) with a total mean of 4.77.

Table 7. The Maintainability Evaluation Result of the Respondents

Maintainability	IT Experts		Printing Services Business Owners		Casual Users		Grand Total Mean	
	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation	Mean	Interpretation
Analyzability Faults be easily diagnosed.	4.90	Very Useful	4.85	Very Useful	4.80	Very Useful	4.85	Very Useful
Changeability • The system can be easily modified.	4.95	Very Useful	4.75	Very Useful	4.85	Very Useful	4.85	Very Useful
Stability • It can continue functioning if changes are made.	4.85	Very Useful	4.90	Very Useful	4.80	Very Useful	4.85	Very Useful
Testability • The system can be easily tested	4.90	Very Useful	4.80	Very Useful	4.90	Very Useful	4.87	Very Useful
Grand Mean	**4.90**	**Very Useful**	**4.83**	**Very Useful**	**4.84**	**Very Useful**	**4.85**	**Very Useful**

Based on Table 7 the evaluation shows that the maintainability of the Printing Vending Machine was evaluated as "Very Useful" confirmed by the IT Experts evaluators who "Strongly Agree" with the "Analysability" (M= 4.90), "Changeability" (M= 4.95), "Stability" (M=4.85), and "Testability" (M= 4.90) with a total mean of 4.90.

Table 8. Summary of Overall Evaluation Results

ISO 25010 Criteria	Mean	Interpretation
Performance Efficiency	4.60	Very Useful
Compatibility	4.71	Very Useful
Usability	4.68	Very Useful
Reliability	4.59	Very Useful
Security	4.74	Very Useful
Maintainability	4.85	Very Useful
Over-all Mean	**4.68**	**Very Useful**

As shown in Table 8, the results confirmed that the Printer Vending Machine has "Very Useful "quality based on ISO 25010 standards. In summation, it has "Very Useful" functional suitability (M=4.57), performance efficiency (M=4.60), compatibility (M=4.71), usability (M=4.68), reliability (M=4.59), security (M=4.74), and maintainability (M=4.85).

With the grand total mean of 4.68, the result validated that the system met the International Standard set by the ISO.

IV. CONCLUSION AND RECOMMENDATIONS

Conclusions:

Based on the results, the following conclusions are:
1. The Internet of Things based Printer Vending Machine was designed, developed, and tested.

2. The project was successfully completed in terms of its intended objectives of providing a printer vending machine that is constantly available to users and provides them with high-quality printed materials at a fair price, a module that can view and save the sales report and a notification module that can notify the operator if an error occurs.
3. The Internet of Things based Printer Vending Machine met the ISO standards in terms of its functional suitability, performance efficiency, compatibility, usability, reliability, security, and maintainability. As expected, the Internet of Things based Printer Vending Machine is suitable for its specific functions and operations.

Recommendations:

Based on the findings and conclusions, the following recommendations are hereby presented:
1. Addition of documents format the machine can print such as .xls, xlsx, ppt and .pptx.
2. Enable wireless printing.
3. User has an option to print specific pages.
4. Improvement in replenishing the coin hopper with one peso, bond papers and ink.
5. Improvement in user management. Individual user accounts will be beneficial in terms of credits, and managing incomplete transactions due to printer related errors.
6. Using other microcontroller like raspberry pi.

V. ACKNOLWDEGEMENT

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