Quickip: Equipment Borrowing System for Laboratory Facilities

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Abstract

The rapid growth of the world wide web and its impact on organizational processes over the years have brought massive information systems development. This study is about the assessment of the current reservation system for laboratory equipment and materials of a higher education institution (HEI) in the Philippines. The use of evaluation tools such as process flowchart and TIMWOODS chart described that the current reservation system has various non-value adding activities and was time-consuming. To address the shortcomings and issues of the current system, an online reservation system called *Quickip* was designed using data flow diagram to illustrate the flow of the process, PHP: Hypertext Preprocessor language for the structure, and Structured Query Language (SQL) for the retrieval and storage of data in the database. The system may be used by students to request for laboratory equipment and materials while the approval of requests will be managed by the faculty/adviser of the borrower, authorized laboratory personnel, and administrative officers. The system also offers inventory management of equipment and allows paperless transactions that will minimize waiting time, reduce traveling or movement of the borrower, and provide real time status of requests.

Keywords
Information system, laboratory equipment reservation, integrated systems

1. Introduction

Technological advancement is unavoidable because companies are competing to outgrow each other, high-tech companies often trigger each other that causes a technological race that pushes for technological advancement (Wang and Qian, 2017). It means that the internet is now more commonly accessible to more people and that communication links have strengthened. It has provided the students with a tremendous sense of educational empowerment through the school automation process. Internet education usage is now manifest in an automated system that is used in a variety of ways to promote productivity (Ossai-Ugbah, 2010).

Information system (IS) is a system that manages not only the set of information but also the way people work, how they operate, their routines (Democ et al., 2015). Information is considered as one of the keys in economic resources since the development of IS in a never-ending process as new versions of software, hardware, and technology is considered. IT is a component of IS as it manages the technical side of the system, from its hardware to its framework. Reservation systems have been proved to reduce the balking effect and probability of delay with a higher server's utilization (Legros, 2017). Information systems and information technology as mentioned, both play a role in making the lives of people easier by reducing such manual efforts in conducting reservations

The use of an online reservation system can also increase the satisfaction of the users since the system can make it easier for the users to book or reserve according to their preferences (Abdullah, et al., 2012). Manual documentation processes can be considered an outdated process in many industries. Performing tasks manually not only consumes a huge amount of time but also raises the risk of data inaccuracy and errors. By developing a web-based application for the reservations of laboratory equipment, it can significantly lessen the risk of manual errors and inaccuracy of the system. This claim can be supported by the study of Sircuse, et al. (2014) where they developed a web-based surgical booking and informed consent system to reduce the potential for errors and improve communication. Delays can also

be minimized by automating manual processes (Glasson, et al., 2012) since a summary of information can be readily accessed by the service provider, thus making an online reservation system more efficient (Royer, et al., 2005).

The importance of continuous process improvement should not only be limited to profit-driving activities. Today, some schools still tend to overlook the importance of innovating some of their outdated processes such as manual documentation systems in laboratories, libraries, and other school facilities. To save cost, most schools opt not to update their systems which can adversely affect the performance of the organization in the long run. While not all activities should undergo major re-engineering, the introduction of technology for process innovation can significantly boost the performance of the school's activities and other services. Automated retrieval solutions are cost-effective and competitive as compared to traditional manual retrieval processes (Caputo, et al., 2018). Similarly, web-based facilities reservation systems bring a positive effect since these systems can successfully solve the lack of facilities management and enable better communication among the school administrators and students in reserving the facilities (Alkhaldi, et al., 2018).

This study provided a solution for the long-existing manual process of reserving equipment in school laboratories. By integrating information systems to improve an existing manual process, a web-based application was developed that can handle the reservation requests of equipment in school laboratories.

2. Methodology

Interviews with the key personnel of a laboratory management office was conducted virtually to gather information on equipment borrowing procedures, policies, and guidelines. For the subject of this study, which is an engineering university in the Philippines, equipment are available for use at the Chemistry Laboratory, Physics Laboratory, Ergonomics Laboratory, and Surveying Laboratory. Further, the equipment lists were also collected from each laboratory personnel. A survey questionnaire using Google Forms was created and given to 150 students who are the users of equipment to know their perception of the current method of borrowing. The survey includes process waste identification, frequency measurement, and factors to consider in designing a proposed system using a 5-point Likert scale. The current borrowing process was illustrated using a process flowchart while the process wastes were identified using various statistical tools such as weighted mean and Spearman’s correlation using SPSS Statistics. An information system tool called data flow diagram (DFD) was created to illustrate the process of the proposed reservation system. Similarly, the user interface of the proposed system was also designed to illustrate how it will be used.

3. Results and Discussion

3.1 Evaluation of the Current Laboratory Equipment Reservation Process

The process of reserving laboratory equipment is illustrated in Figure 1. Students visit the respective laboratory assistant to ask availability of the desired equipment. A laboratory equipment reservation form shall be accomplished in two (2) copies if the desired equipment is available and be submitted for signature of the respective dean, course adviser, and laboratory assistant for approval. Once the request is approved, the equipment will be pulled out and given to the borrower. Copies of the form are then submitted to the laboratory management office and the laboratory assistant for file keeping. Since only two (2) copies of the form is available, the borrower will be required to photocopy it to have a personal copy. In cases when the equipment is to be brought outside of the campus premises, the borrower needs to submit a copy of the laboratory equipment reservation form and request for a gate pass from the campus maintenance office. The gate pass indicates the type of equipment borrowed and must be signed by the head of the laboratory equipment department and the campus maintenance office to signify approval. Since only one (1) copy of the gate pass is available, the borrower will again be required to photocopy the signed gate pass for personal copy. The reservation process more often takes up too much time when the personnel in-charge is not present during the day. Students/borrowers are prompted to visit the respective offices from time to time since the process requires approval of several departments. Thus, waiting for approval of the requested equipment causes delay in the reservation process which usually takes one to two days.

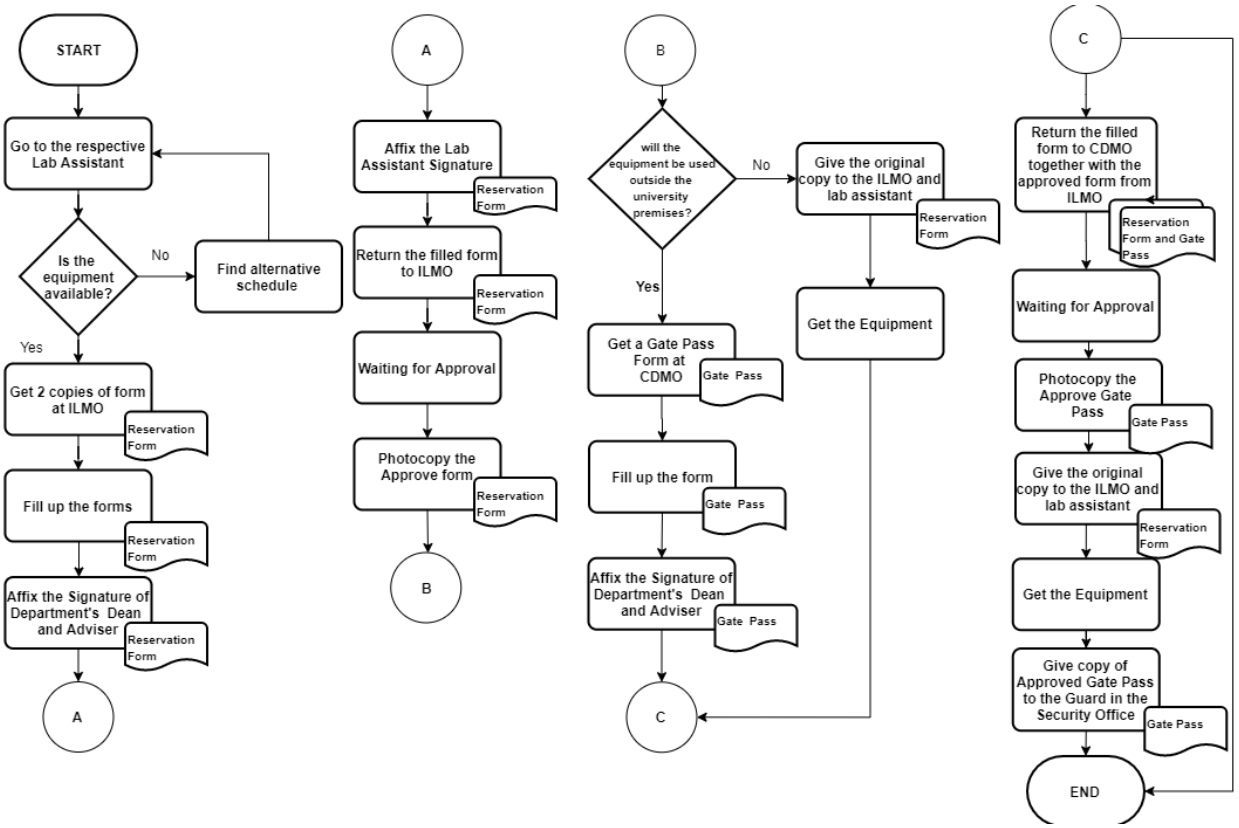

Figure 1. Laboratory Equipment Reservation Process

3.2 Process Wastes Elimination Using TIMWOODS

TIMWOODS, a tool that is associated with identifying and eliminating waste which is an action that does not add value in a process (Skhmot, 2017), was used to present the process wastes in the current equipment reservation process. Table 1 shows the wastes analyzed using TIMWOODS. A total of eight (8) wastes were identified through process mapping and survey. These include too much movement from one department to another, manual list of equipment inventory, too much unnecessary movement such as manual filling of the form, time spent on waiting for the availability of the respective department's person-in-charge for approval, multiple signatories/approver of the form, photocopying of the form for personal safekeeping, data and schedule inaccuracy brought by the manual reservation method, and unexpected absence or unavailable concerned personnel.

Table 1. TIMWOODS Analysis

Type of waste	Impact	Description
Transport	Moving from one place to another, Movement of items and information	Students need to go to the following offices to borrow equipment: - laboratory room where the concerned lab assistant is stationed (to check the availability schedule) - integrated lab oratory office (to get copies of the reservation form) - laboratory room, integrated lab oratory office, faculty room, and Dean's office (to get their signature as a sign of reservation approval)
Inventory	Items or Information that customer has not received	The integrated laboratory office does not have a computerized data base to store their inventory list and request/process forms

Motion	Unnecessary movement	Students manually fill-up multiple copies of the form
Waiting Times	Waiting for information or items to arrive	Students more often visits the lab assistant's station more than necessary Students need to wait for the approval due to the unavailability of the faculty/adviser
Over-Processing	Doing more work than necessary	Students manually fill-up multiple copies of the form Students needs to get the necessary signatures from concerned personnel (faculty/adviser, admin officers, authorized laboratory personnel)
Overproduction	Making too much of something	Copies of the form are needed due to manual recording and storing of data
Defects	Mistakes and errors that need to be reworked	The manual process of reservation is prone to documentation errors
Skills	Unused talent waste	Frequently unavailability of concerned personnel (faculty/adviser, admin officers, authorized laboratory personnel)

3.3 Weighted Mean of Survey Responses

The weighted mean of each responses was computed to provide a descriptive interpretation of the rating of the borrowers with regards to the current equipment reservation process. To calculate the weighted mean, which is more accurate than getting the regular average in which all numbers in a data set are assigned an identical weight (Ganti, 2020), a predetermined weight was multiplied first by a number in the data set. Tables 2 and 3 show the descriptive interpretation for each degree of measurement along with the respective scale range while Table 3 presents the weighted mean of each waste identified in the process.

Table 2. Descriptive Interpretation of Weighted Mean of Responses: Identified Waste

Scale	Scale Rage	Degree of Measurement	Verbal Interpretation (Description of Identified Waste)
5	4.01-5	Strongly Agree	The student strongly agrees to the waste identification
4	3.01-4	Agree	The student agrees to the waste identification
3	2.01-3	Neutral	The student is neutral to the waste identification
2	1.01-2	Disagree	The student disagrees to the waste identification
1	0-1	Strongly Disagree	The student strongly disagrees to the waste identification

Table 3. Descriptive Interpretation of Weighted Mean of Responses: Characteristics of the Reservation System

Scale	Scale Rage	Degree of Measurement	Verbal Interpretation (Characteristics of the Reservation System)
5	4.01-5	Very Important	Characteristic of a system is very important to the student
4	3.01-4	Important	Characteristic of a system is important to the student
3	2.01-3	Moderately Important	Characteristic of a system is moderately important to the student
2	1.01-2	Slightly Important	Characteristic of a system is slightly important to the student
1	0-1	Not Important	Characteristic of a system is not important to the student

It can be observed from Table 4 that all wastes identified in the process has a calculated weighted mean of 4.01 and above. This signifies that the borrowers strongly agree that these wastes are indeed present in the current equipment borrowing process and should be eliminated to achieve process efficiency. Similarly, the factors that should be considered in an improved equipment borrowing process, presented in Table 5, also resulted to weighted means of above 4.01. This denotes that responsiveness, ease of use, security, usefulness, web appearance, service quality, information quality, and system quality are the important attributes that should be considered in designing an efficient borrowing system.

Table 4. Weighted Mean of Wastes Identified

Waste Identified	Mean	Description
Transportation Waste	4.09	Strongly Agree
Motion Waste	4.22	Strongly Agree
Inventory Waste	4.14	Strongly Agree
Overprocessing Waste	4.34	Strongly Agree
Overproduction Waste (Photocopying)	4.17	Strongly Agree
Waiting Waste	4.25	Strongly Agree
Skills Waste	4.31	Strongly Agree
Overproduction Waste (Multiple Forms)	4.16	Strongly Agree
Defects Waste	4.03	Strongly Agree
Grand Mean	**4.71**	**Strongly Agree**

Table 5. Weighted Mean of Characteristics of the Reservation System

Characteristics	Mean	Verdict
Responsiveness	4.43	Very Important
Ease of Use	4.38	Very Important
Security	4.31	Very Important
Usefulness	4.46	Very Important
Web Appearance	4.03	Very Important
Service Quality	4.49	Very Important
Information Quality	4.49	Very Important
System Quality	4.51	Very Important
Grand Mean	**4.39**	**Very Important**

3.4 Spearman's Correlation

The correlation coefficient of Spearman is a statistical measure of the intensity of a monotonous relationship between the data sets (Zhou, 2020). A 5-point Likert scale was assigned to each responses in the survey to acquire a numeric value on each response: 5 for Strongly Agree, 4 for Agree, 3 for Neutral, 2 for Disagree, and 1 for Strongly Disagree. Table 7 shows the summary of correlation analysis based on Spearman's Correlation Coefficient in Table 6. The Spearman's correlation is denoted by rs and is designed by constraints: the closer the correlation coefficient to one, the stronger the monotonic relationship (Alnassar, 2020).

Table 6. Spearman's Correlation Coefficient

Spearman's Correlation Coefficient	Strength of Correlation
0.80 - 1.00	Very Strong
0.60 – 0.79	Strong
0.40 – 0.59	Moderate
0.20 – 0.39	Weak
0.00 – 0.19	Very Weak

The four (4) comparisons made were transportation and overprocessing, waiting and skills, overproduction and inventory, and transportation and waiting. The results exhibited in Table 6 showed that transportation and

overprocessing and overproduction and inventory have strong correlation while waiting and skills and transportation and waiting have moderate correlation. This implies that as one type of waste appears, the other type will also occur in the process.

Table 7. Summary of Correlation between Wastes Identified

Type of Wastes	Correlation Value	Description
Transportation and Overprocessing	0.603	Strong
Waiting and Skills	0.589	Moderate
Overproduction (Forms) and Inventory	0.602	Strong
Transportation and Waiting	0.585	Moderate

3.5 Design of Online Equipment Borrowing System

3.5.1 Data Flow Diagram

A data flow diagram (DFD) is used to graphically present the flow of data and visually show how each department of an organization works with each other (Ibrahim and Yen, 2010). Figure 2 shows the DFD of the proposed online reservation system. It consists of six (6) processes and three (3) data storage. In addition, four (4) entities were included in the system which are the student, admin officer, faculty/adviser, and authorized personnel. The first process is the log-in process, where the user (student, admins, authorized personnel, faculty staff) will be requested to provide his account details and be stored in data storage. After logging in, the student must proceed to the next process which is the equipment borrowing process. In this process, the equipment is listed together with its availability status. After submitting the borrowing form, the request details will then be stored in the request data storage. The third process is the borrowing request approval which will include a notification to the faculty/adviser, authorized personnel, and admin officer. This process will also provide a notification regarding the status of request to the student. The manage equipment process, on the other hand, allows the authorized personnel to edit the equipment status and be saved in the inventory data storage. The gate pass approval, which is only applicable for request to use the equipment outside of the campus premises, permits the concerned user to approve the gate pass requests which is an administrative task. The last process is about managing inventory where the admin officer and authorized personnel are given access to update the equipment list in the inventory data storage.

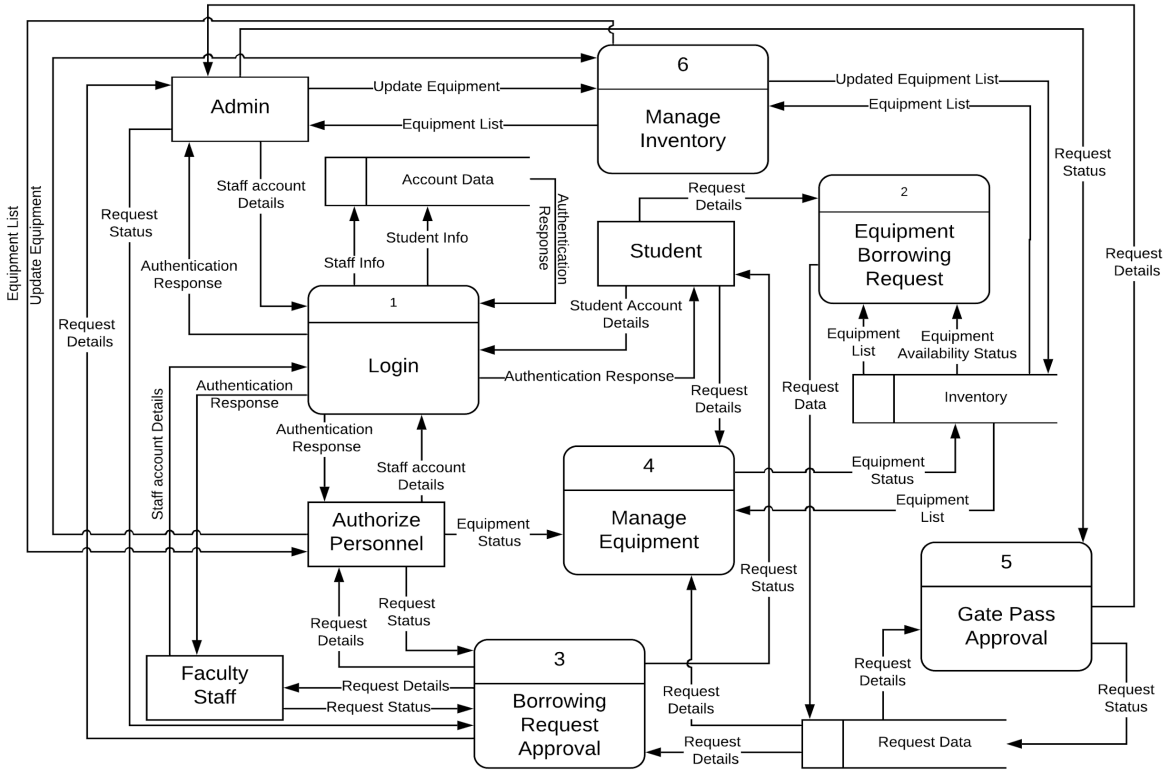

Figure 2. Data Flow Diagram of Proposed Equipment Borrowing System at Level 0

3.5.2 *Quickip*: An Online Equipment Borrowing System

A proposed equipment borrowing system called *Quickip* was designed to eliminate the wastes identified in the current system and ensure that system efficiency will be achieved by both the users and the servicing department. Online borrowing systems also help eliminate common problems experienced on manual documentation and unavailability of personnel in-charge and provide proper coordination and communication between the requestor and facility managers (Barzaga et al, 2019).

An interface illustrates where and how the user and the system interact with each other. There are total of four (4) external entities or users will be involved in *Quickip* system and these are the student, admin officer, faculty/adviser, and authorized personnel. Each user will have his own interface that allows for various functionalities. The system was designed using PHP: Hypertext Preprocessor language while the databases utilized the Structured Query Language (SQL) to communicate, retrieve, and store data. Figure 3 shows the student/borrower's request form interface where a dropdown list of laboratory equipment is present and should be selected to proceed to the next fields. The succeeding fields include purpose of use, date and time of request, request for extension, request for gate pass, and remarks. The equipment list is displayed when the "Add Item" button is clicked. Students can also put their desired quantity to borrow but a limit on the no. of equipment will be set in the system.

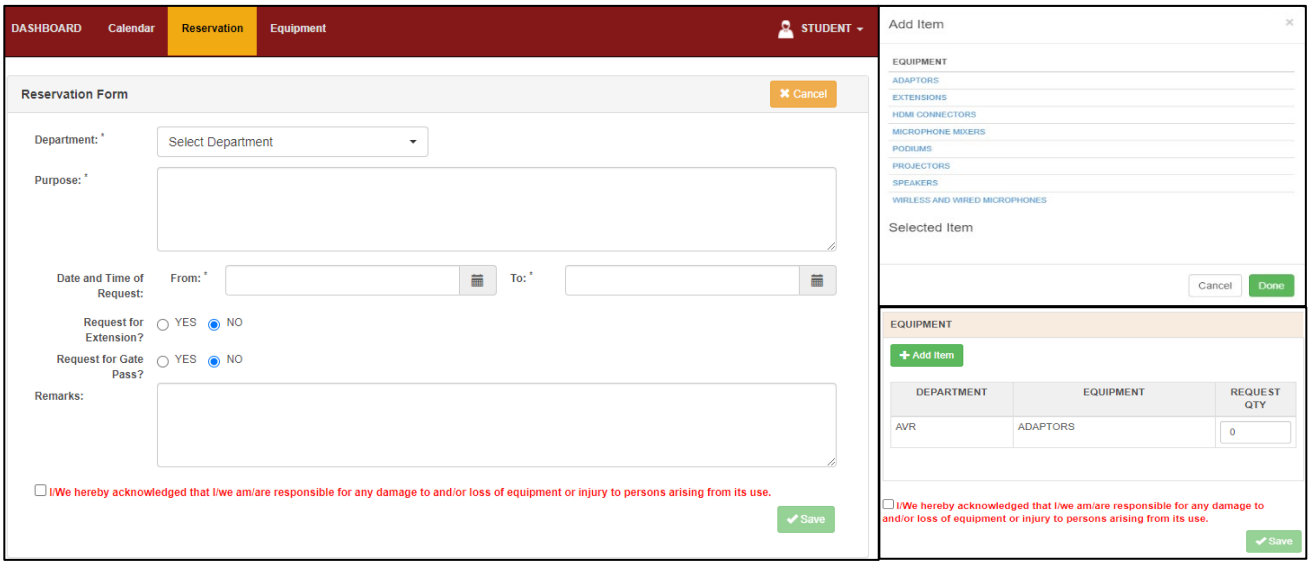

Figure 3. Reservation Request Form and Adding Equipment

Figure 4 shows the reservation form where the accomplished form appears in an organized format and all users can view or print the form. It also shows the list of equipment requested by the students and its corresponding condition, quantity, and claim status. Below the accomplished reservation form is the section for the signature of each person required to approve the request and signature of the borrower. The status will also show the progress of the approval of request by the admin officer, faculty/adviser, and authorized personnel. The Inventory Tab will be available only to the authorized personnel who will manage the inventory of equipment. The equipment will be clustered or categorized for each type of laboratory for easy access. The authorized personnel can edit the on-hand column by clicking the physical count button and manually input the desired quantity.

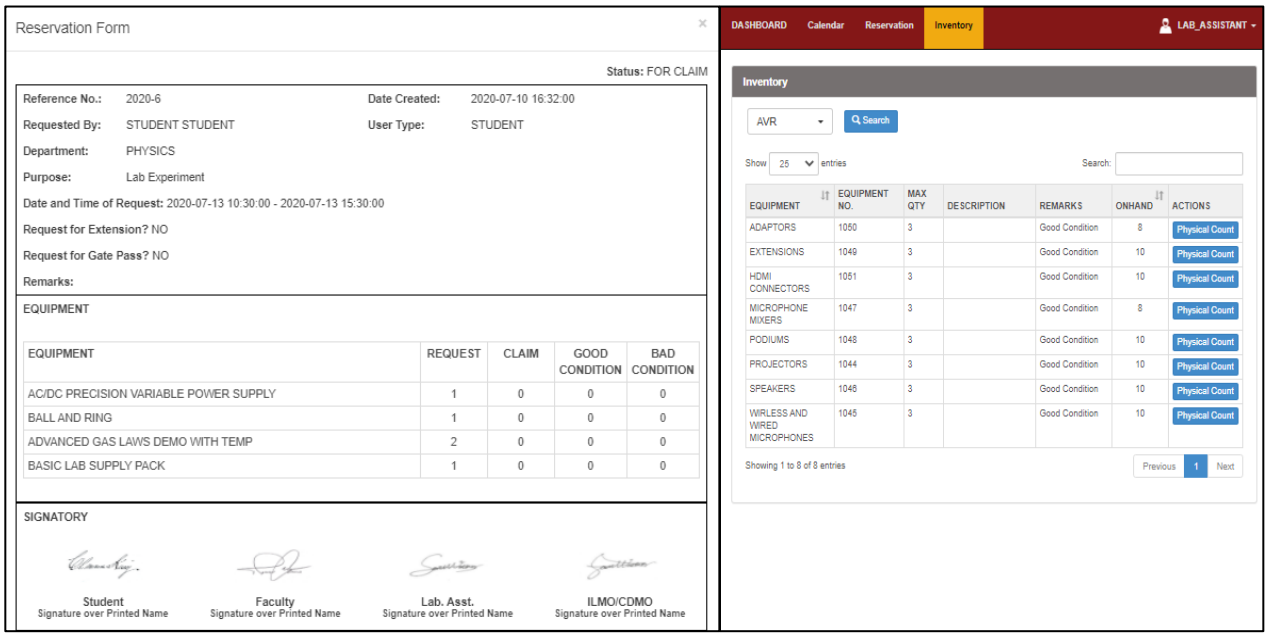

Figure 4. Approved Reservation Form and Inventory Tab

The Pending Requests shown in Figure 5 is displayed on the dashboard of the concerned personnel's account. It is also the section where the personnel can approve or disapprove the borrow request. There are three (3) hierarchy of

approval involved to borrow an equipment: the faculty/adviser, laboratory assistant (authorized personnel), and admin officer. The student's request will appear on the admin officer's Pending Request section where the Approve or Cancel button will appear beside the request. The system also shows the reservation tab which provides all users the ability to view the details of request entries made by the students. The tab also shows whether the equipment has been claimed or received depending on what the authorized personnel would input to the system.

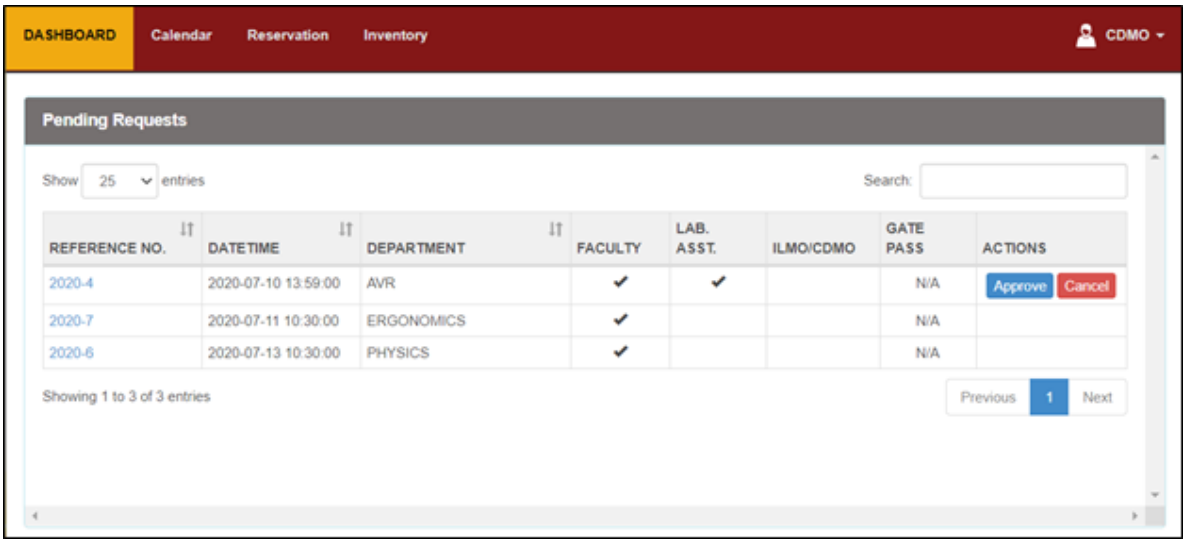

Figure 5. Approval Interface

The Authorized Personnel Interface exhibited in Figure 6 will be handled by the department's assigned authorized personnel. It consists of Pending Requests, Approved Requests, and Claimed Requests sections. The Pending Requests Section is where the student's request will appear and where the authorized personnel is to approve the request. The approved borrowed request will appear in the Approved Requests section. It is also where the authorized personnel will click the "Claim" button when the student shows the request reference.

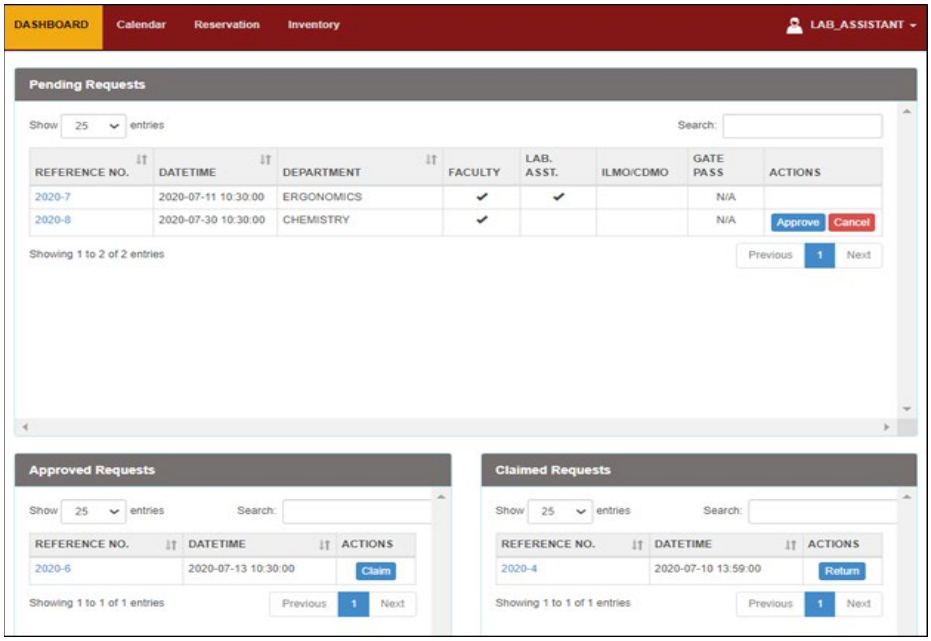

Figure 6. Authorized Personnel Interface

4. Conclusion

The evaluation of the current laboratory equipment and materials reservation process of the subject HEI presented eight (8) types of process wastes which are too much movement from one department to another, manual list of equipment inventory, too much unnecessary movement such as manual filling of the form, time spent on waiting for the availability of the respective department's person-in-charge for approval, multiple signatories/approver of the form, photocopying of the form for personal safekeeping, data and schedule inaccuracy brought by the manual reservation method, and unexpected absence or unavailable concerned personnel. These were presented using TIMWOODS analysis. To eliminate the non-value adding activities and redundancies found in the current system, an online reservation system called *Quickip* was designed for use by the student/borrower and concerned personnel. The system will automate the manual borrowing of laboratory equipment and materials in the HEI and will help decrease the travel times and waiting times of the students. It will also allow faster processing of requests which will lead to increase their productivity of the personnel in the servicing department and efficiency of the reservation process. Similarly, *Quickip* will also enable paperless transactions which will lead to reduce consumption of papers, efficient data storage management, and enhanced security in record keeping. Management and tracking of equipment will also be achieve which will result to better inventory management. The *Quickip* interface was designed to be user friendly and convenient to use which will optimize all the equipment resources available in the HEI.

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