Design of Customer-driven Facility Management System for Universities

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Abstract

Reservation and monitoring of facilities are some of the regular activities in management of facilities in academic institutions. However, there are similar problems being encountered by users such as identifying the available facilities that can be used, securing approval for request if signatories are not available or loss of documents mainly because the processes are being done manually. This paper presents the design of Facility Management System based on customer requirements. Using criteria analysis, technical specification alternatives were defined and the best option that will satisfy the customer requirements had been selected and incorporated in the design of the automated system. A prototype was made and tested to group of users. The results showed significant improvement in the reservation and monitoring processes in terms of the level of customer satisfaction.

Keywords
Information systems, Criteria Analysis, User Interface

1. Introduction

Facility, being one of the perceived components of quality education should be managed well. Nwagwu (1978) and Ogunsaju (1980) stated that the quality of education that children receive bears direct relevance to the availability or lack of physical facilities and overall atmosphere in which learning takes place. Research findings have also shown that students learn better when a combination of methods and materials are employed during teaching. Thus, education system requires the provision, maximum utilization and appropriate management of facilities. Advances in science and technology should be employed in facilities management (specifically, reservation and monitoring processes) of the universities to provide accurate, exhaustible and updated information. This can also be done through a centralized device and channel for communication among related parties such as students and administrative heads and staff. This study aimed to develop an automated information system that will aid in facility management and provide users satisfaction.

The authors conducted the study in two of the engineering schools in the Philippines. Users are classified into two types: Type 1 Users or the students and Type 2 Users or the Facility Managers and laboratory technicians for both laboratories and common facilities such as seminar rooms. Three hundred ninety-eight (398) respondents were interviewed from University 1 and three hundred fifty four (354) were from University 2. Out of the total number of respondents from each institution, 20 were Type 2 Users. Both users were interviewed in order to assess their experience with the current processes, the areas for improvement and to get ideas on how the automated system is

expected to work. The processes included in this study are only those that are common to both institutions such as the Process of Reservation for Common Facilities and Equipment, Borrowing of Laboratory Equipment for Regular Classes, Receiving of Laboratory Equipment, Handling Losses and Breakages of Equipment and Tools and, Reservation of Laboratory Facilities and Equipment Outside of Class Hours

2. A Customer –driven design Methodology

2.1Users Experience with the Current System

Through interviews and observation, the researchers identified the weaknesses in the detailed processes below:

Table 1 Reservation of Laboratory Equipment and Common Facilities

Process	Weakness
1. Requester gets application form from designated office	Person in-charge who issues the form is not in his post, thus, makes the requester wait.
2. Requester fills up the form.	Forms should be filled out in multiple copies and this consumes longer time. Also in this process there is no assurance that the facility being requested is still available unless the requester will ask the facility custodian.
3. Requester asks for approval and submit form.	Signatories are not available which delays the process.
4. Facility staff checks availability details and validates the request.	Since checking of availability and validation process are manually done, the staff has a tendency to commit a mistake that a particular facility/equipment has already been reserved. In cases like these, there are times that students are not being notified by the staff . During cancellation of request, students do not inform the staff thus, the available facility has not been updated.
5. Requester gets the copy of the application.	There are instances that documents are misplaced resulting to delay in issuance to requester.

2.2 Identifying Customer Requirements

As the result of the investigation, the needs of each type of users were defined as follows:

Table 2 Needs of Type 1 and Type 2 Users

Type 1 Users	Type 2 Users
The person who is in-charge of their concern is immediately available to them	More presentable way of showing the schedule of the facilities
The procedure for their transaction is clearly stated	Immediate contact with them whenever a user changes his mind about the reservation
Modifiable viewing of the schedule of the facilities	Easier searching of files
More presentable way of showing the schedule of the facilities	Easier sorting of information
Less people to personally visit for their transaction	Better designed forms
Better designed forms	More adaptive means of monitoring metrics
Proper handling and safe-keeping of forms	Have a balanced schedule for catering to user's request and personal work
Immediate contact with them whenever a concern arises	

2.3 Technical Specification Alternatives

The researchers interviewed technical experts to know the technologies that may be used in order to fulfill the requirements of both type of users.. Below are the given alternatives:

- Reliable and scalable databases using MongoDB – MongoDB is document database in which one collection holds different documents. Number of fields, content and size of the document can differ from one document to another. It has a deep query-ability. MongoDB supports dynamic queries on documents using a document-based query

language that's nearly as powerful as SQL. It is usually used in big data, content management and delivery, mobile and social infrastructure, user data management and data hub (Advantages of MongoDB over RDBMS, 2014).

- Bcrypt Encryption for storing user password- Bcrypt is a cross platform file encryption utility. Encrypted files are portable across all supported operating systems and processors. Passphrases must be between 8 and 56 characters and are hashed internally to a 448 bit key. However, all characters supplied are significant. The stronger your passphrase, the more secure your data (Shelley, 2002)
- Reliable App Server using Node.js Library and Express.js- Node.js is a programming platform that allows you to execute mostly server-side code that is identical in syntax to browser JavaScript. But in browser we are limited in using all language possibilities as we have to provide security for user. In such case usually all activity is aimed to DOM-manipulation and also asynchronous page info loading. Node.js opens up new perspectives, still having its "browser" nature (Pankova, 2014).

Express is a minimal and flexible Node.js web application framework that provides a robust set of features to develop web and mobile applications. It facilitates a rapid development of Node-based Web applications (Node.js - Express Framework, 2013).

- Responsive UI using Bootstrap 3- Bootstrap is a sleek, intuitive, and powerful, mobile first front-end framework for faster and easier web development. It uses HTML, CSS and Javascript. Bootstrap's responsive CSS adjusts to Desktops, Tablets and Mobiles (Bootstrap - Overview, 2012).
- Web Component using React.js - React is a library for building composable user interfaces. It encourages the creation of reusable UI components which present data that changes over time (Hunt, 2013).
- 24/7 uptime and scalable servers using Amazon EC2 - Amazon Elastic Compute Cloud (Amazon EC2) provides scalable computing capacity in the Amazon Web Services (AWS) cloud. Using Amazon EC2 eliminates your need to invest in hardware up front, so you can develop and deploy applications faster. You can use Amazon EC2 to launch as many or as few virtual servers as you need, configure security and networking, and manage storage. Amazon EC2 enables you to scale up or down to handle changes in requirements or spikes in popularity, reducing your need to forecast traffic (What Is Amazon EC2?, 2011).
- Asset Management using Amazon S3 - Amazon Simple Storage Service (Amazon S3), provides developers and IT teams with secure, durable, highly-scalable object storage. Amazon S3 is easy to use, with a simple web service interface to store and retrieve any amount of data from anywhere on the web (Amazon S3, 2011).
- Real time messaging - Firechat is an open-source, real-time chat widget built on Firebase. It offers fully secure multi-user, multi-room chat with flexible authentication, moderator features, user presence and search, private messaging, chat invitations, and more (Firechat, 2013).

2.4 Criteria Analysis

The researchers simplify the presentation of the customer requirements as follows:

(1)Improvements in presentation of information, design of forms, safekeeping of documents, communications between type 1 and type 2 users, adaptability to user's preferences and capability of monitoring information.

(2)Increase user options and systems availability.

(3) Decrease user's waiting time and user's travel time in different offices.

Using criteria analysis as a tool to decide on which technical specification is best in the design of the automated system, each customer requirement was rated based on its importance to the users and represented by criteria weight in percentage, while each alternative was rated by the technical experts based on its capability to satisfy the customer requirements and represented by scores from 1 to 5 (1 is the lowest and 5 is the highest T). Weighted scores were calculated by multiplying the rating of alternative to the criteria weight of the customer requirements. The alternative Amazon Webservice EC2, which has the highest total score was selected and incorporated in the design of the Reservation and Monitoring System. Table 3 shows the criteria analysis matrix.

Table 3 Criteria Analysis Matrix

Customer Requirements (Criteria)		Crieria Weights	Alternatives															
			Mongo DB		Bcrypt Encryption		Node.js		Bootsrap 3		React.js		**Amazon Webservice EC2**		Amazon S3		FreeBase Service	
			Score	Wtd. Score	Score	Wtd. Score	Score	Wtd. Score	Score	Wtd. Score	Score	Wtd. Score	**Score**	**Wtd. Score**	Score	Wtd. Score	Score	Wtd. Score
Improve	Presentation of information	10.81	5	54.054	0	0	3	32.43	4	43.2	3	32.43	**3**	**32.43**	4	43.24	0	0
	Design of forms	10.81	3	32.432	0	0	2	21.62	4	43.2	0	0	**0**	**0**	4	43.24	3	32.43
	Safekeeping of documents	8.11	0	0	5	40.54	4	32.43	0	0	0	0	**0**	**0**	4	32.43	0	0
	Communications between type 1 and type 2 users	8.11	0	0	3	24.33	4	32.44	3	24.3	5	40.55	**5**	**40.55**	0	0	5	40.55
	Adaptability to user's preference	13.51	4	54.054	0	0	1	13.51	3	40.5	4	54.05	**5**	**67.57**	0	0	3	40.54
	Capability in Monitoring Information	13.51	5	67.55	3	40.53	3	40.53	3	40.5	3	40.53	**5**	**67.55**	5	67.55	0	0
Increase	User Options	8.11	2	16.22	0	0	1	8.11	5	40.6	0	0	**5**	**40.55**	5	40.55	3	24.33
	Systems Availability	10.81	0	0	0	0	5	54.05	0	0	5	54.05	**5**	**54.05**	5	54.05	5	54.05
Decrease	User's waiting time	8.11	4	32.44	0	0	3	24.33	0	0	5	40.55	**3**	**24.33**	0	0	3	24.33
	User's travel time to different offices	8.11	2	16.22	0	0	3	24.33	0	0	5	40.55	**3**	**24.33**	0	0	3	24.33
	Total			273		105		284		232		303		**351**		281		241

2.5 Conceptual Design

Figure 1 shows the dataflow diagram of the proposed Facility Management System and illustrates the different processes incorporated in the design. These are the Online Reservation System for Type 1 Users; Handle Equipment, Edit Policy and Make Schedule for Type 2 Users; and User Sign-up, User Log-in and Mail System for all the users of the system.

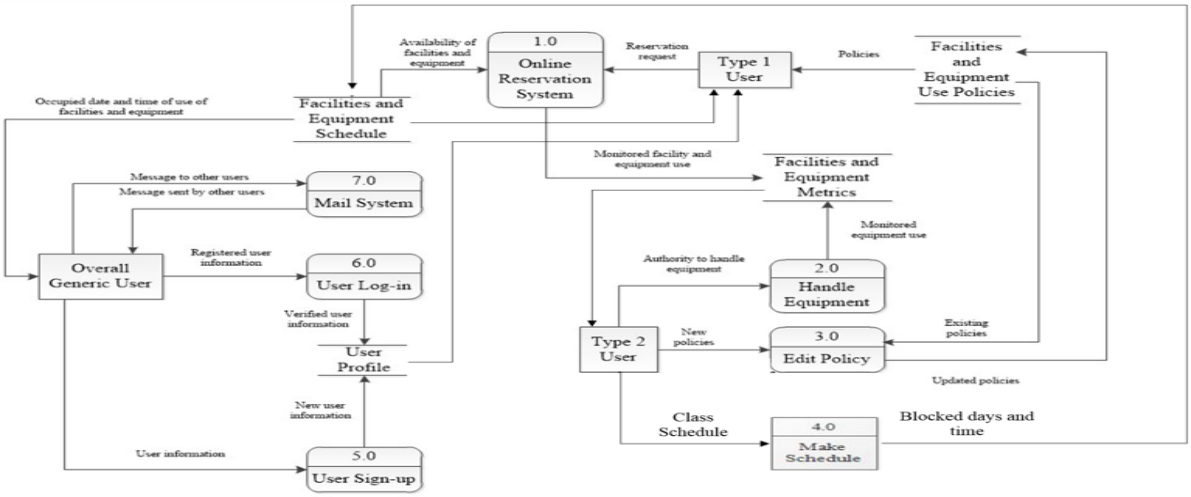

Figure 1 Dataflow Diagram of Facility Management System

The researchers assigned a code to each type of user to determine which interface will be displayed once a user logs-in to the system. However, an Overall Generic User represents all the users of the system since common processes such as Process 5.0- Sign-up and Process 6.0- Log-in and the database of the schedule of facilities and equipment use can be accessed by the two types of user.

The Online Reservation process will be accessed by the Type 1 users and it has 4 reservation options:

- Reserve Common Facilities – common facilities of an institution are those that are mainly used for the purposes of large academic-oriented activities that are extensions of classroom activities. Furthermore, common facilities can be also used in extra-curricular activities such as organizational or departmental. In this process, the user is presented a list of available common facilities and equipment that he can reserve. Once the user is done with reserving a facility, the requested facility and equipment will be stored into their respective database.
- Reserve Laboratory Equipment for Laboratory Classes – the user in this case is an enrolled student in a laboratory class. The user will be presented with laboratories that his class may be located in. Also, a list of laboratory equipment will be presented to the user. From there, he will have the option to choose the laboratory equipment that he will be needing for his laboratory class. The chosen laboratory equipment by the user will then be stored in the database.
- Reserve Laboratory Facilities and Equipment – the user in this case can be either a student or a faculty member. Laboratories and Laboratory Equipment for outside of scheduled classes can be reserved in this function. The user will be shown a list of available slots for the facility and if the user wants to reserve a laboratory equipment, he can also do so in this option. Furthermore, the user will also have an option if the laboratories that he wants to reserve is a computer laboratory.

The Handle Equipment process which is accessible to Type 2 users covers the following functionalities:

- Receive Equipment – this function will be used for receiving a borrowed equipment. From the database, the system will display the list of borrowed equipment of a certain user and then once the borrowed equipment is checked that it is complete and not broken, the Type 2 User will input that the borrowed equipment are returned.
- Clear Student – this function is to be used whenever a student or a borrower misplaces or breaks a laboratory equipment or tool. The input of the Type 2 User will reflect on the facility and equipment metrics and on the user profile of the concerned user.

The Edit Policy process will enable Type 2 Users or the administration to edit the information that they relay to the users of the system without having the need to ask help from a programmer. However, this function is only limited to user agreement and policies. The default view in this page are the existing policies in the system.

- Add Policy – this enables the user to add a policy to the existing policies in the system.
- Edit Policy – this enables the user to revise the existing policies in the system.
- Delete Policy – this option is available to the user if he wants to remove a policy that is no longer followed in the system.

The Make Schedule process will enable the facility manager to set the period of terms for the school year as well as reserve a facility, time and day for classes that are recurring for a set period of time. The reserved facility, time and day for a class will be unavailable to be reserved by a Type 1 User for that period of time. This function is only available for laboratories and computer laboratories.

The Mail System functionality will enable the user to contact other users of the system within the system without having to use their personal resources.

- Compose Messages – this is the primary function of the process wherein users can compose and send messages to other users.
- Reply to Sender – this will enable the user to reply immediately to those who have sent him a message.

2.6 User Interface Design

After the flow of processes has been established, the researchers designed user interface of the system. These show the contents and functionalities of the system. Figures 2 - 5 are screenshots of the main function of the system for Type 1 Users which is the Online Reservation System. This function is solely available to them. The users can reserve common facilities, laboratories and equipment that supplement their activity. It is shown in Figure 2 that a policy of four days prior the activity is the minimum allowed number of days for a user to reserve a facility. Figure 3 shows that the real-time availability of equipment in the inventory was also incorporated in the system. A User Profile page (Figure 5) was also designed to summarize the reservations that the user made throughout the use of the system. The user can also cancel a maximum of two reservations within the term. Breakages and losses of equipment are also recorded in this page specifically in the "Issues" tab.

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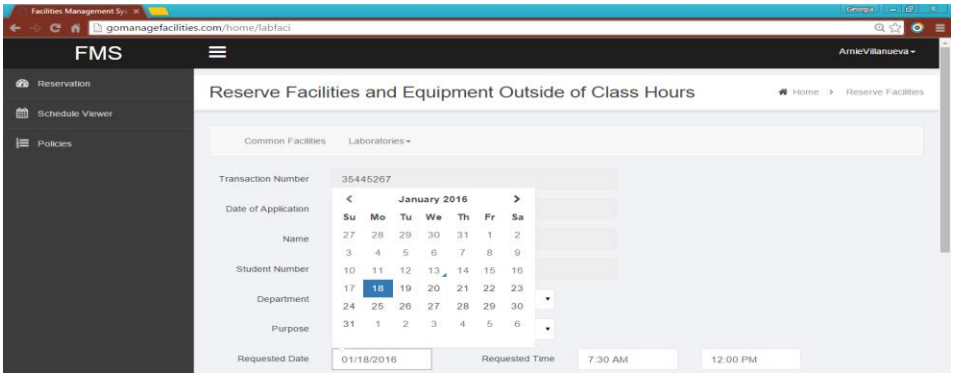

Figure 2 Laboratory Reservation-A

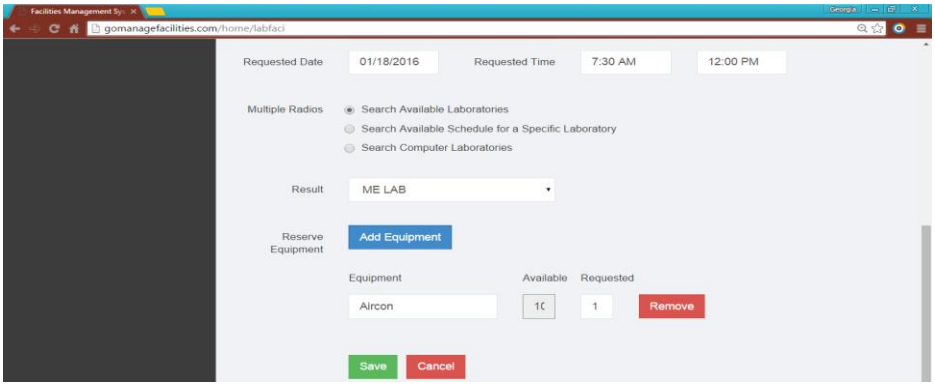

Figure 0 Laboratory Reservation-B

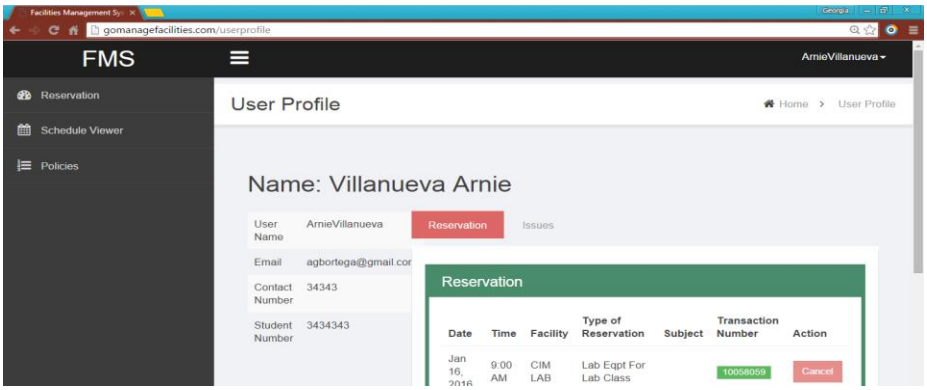

Figure 4 User Profile

Figures 5 to 7 are interfaces available to laboratory assistants who are tasked to monitor, deploy and assist users with laboratory equipment. A limitation of the system is evident in Figure 7 wherein the laboratory assistant shall view the uploaded receipt of equipment loss or breakage by the user. Since the system is not integrated with any system of any institution, manual checking of the paid fine is done by the laboratory assistant to make sure that the rightful payment was done by the user.

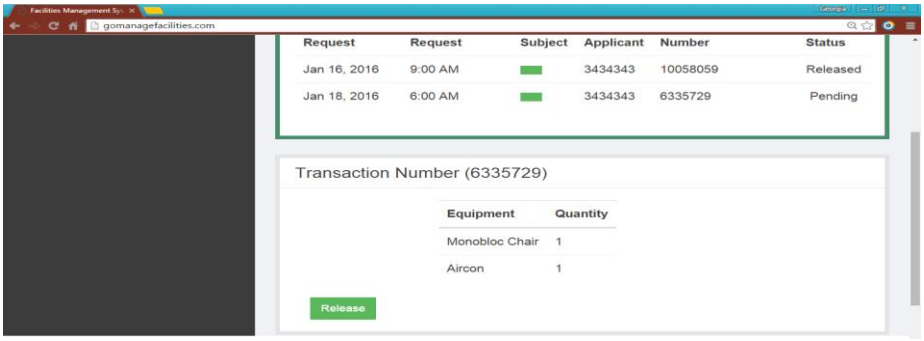

Figure 5 Equipment Reservation

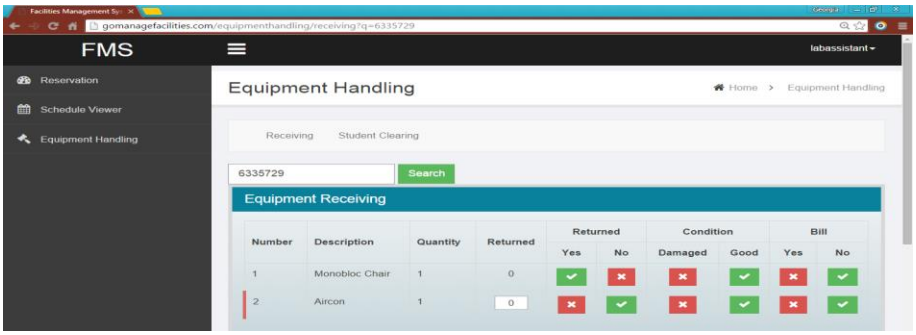

Figure 6 Equipment Receiving

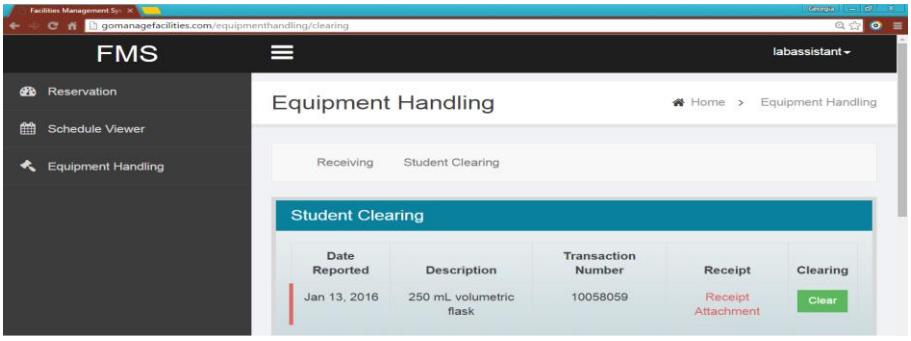

Figure 7 Student Clearing

Lastly, Figures 8 to 13 are interfaces exclusively used and viewed by the Facility Manager. The Facility Manager can reserve a facility for a whole term that is intended to be used for scheduled classes (Figures 8 and 9).

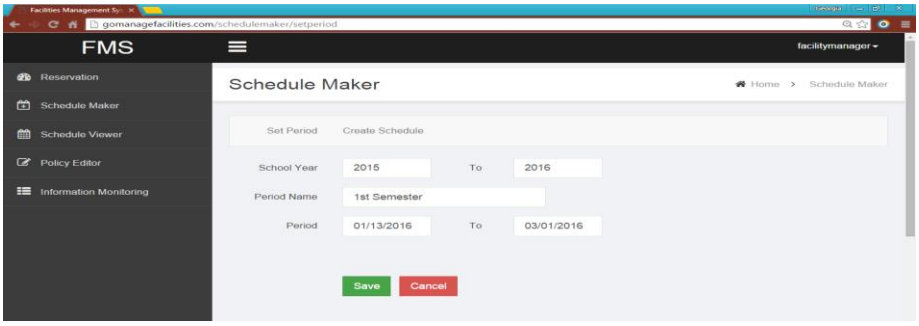

Figure 8 Set Period

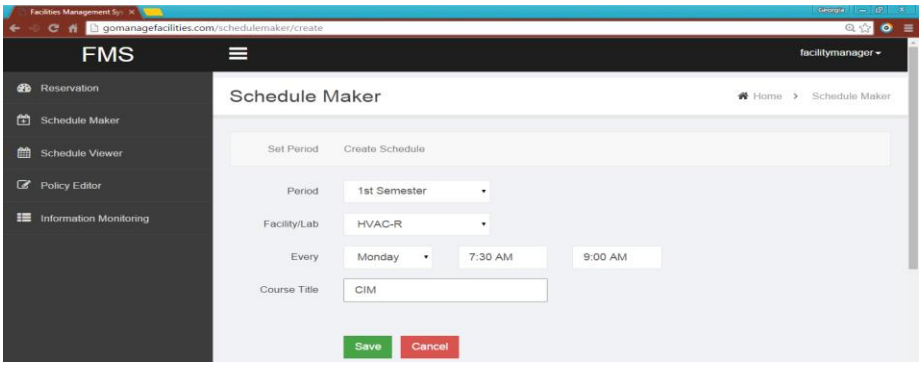

Figure 9 Create Schedule

Figures 10 to 12 are monitoring functions of information that are used throughout the system. This information can be printed as a report through the Print capability of any browser. This function removes the necessity of the user to manually sort information and improves searching them since their source and destination are the same.
Functions of the system that are common to all users are the Schedule Viewer that displays real-time facility schedule and the Mail System that enables users to conveniently communicate through the system.

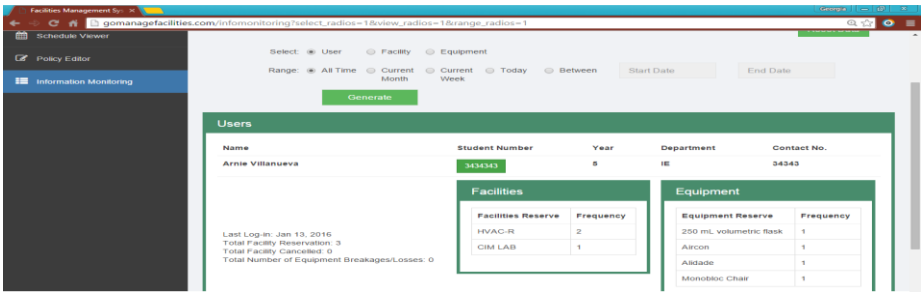

Figure 10 Monitor User Information

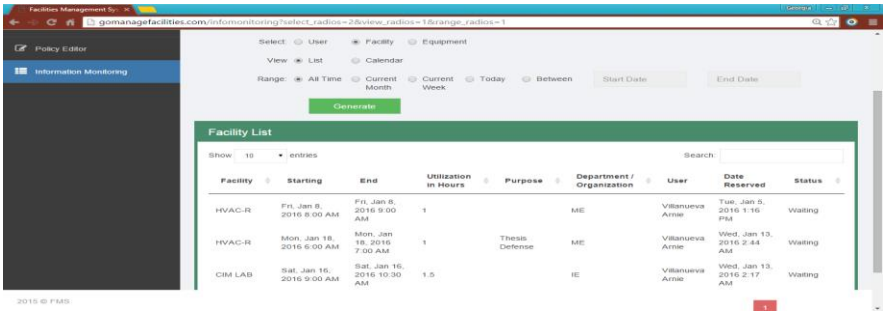

Figure 11 Monitor Facility Information

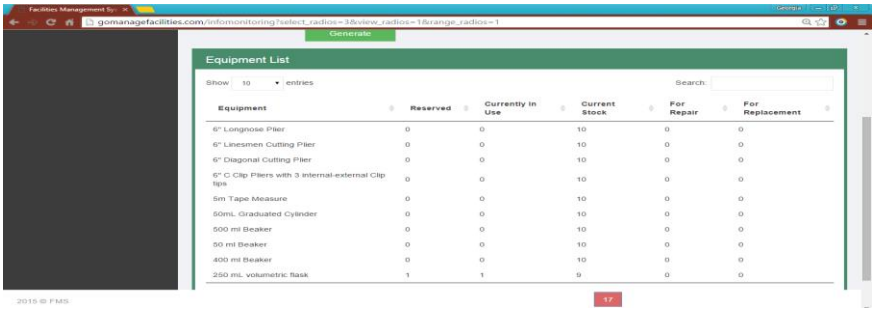

Figure 12 Monitor Equipment Information

3. Results and Discussions

In order to determine the efficiency of the current system, the researchers prepared a survey questionnaire for Type 1 and Type 2 users covering set of performance measurement factors that will be rated by them. This set of questions had also been used to assess the performance of the proposed system. Questions are categorized into seven (7) criteria as follows:

a. Responsiveness – Requests are available to its users and does not require any amount of waiting time.
b. Reliability - Provides suitable services that are intended to deliver its purpose as well as factual and complete information.
c. Competence - Fully adequate in addressing its users' issues and is able to solve all users' problems.
d. Communication - Provides its users important, clear and accurate information at all times
e. Convenience - Available for use and access by all its users whenever they want.
f. Ease of use- Simple and easily used by its users.

g. Security - Strict boundaries before one can access different kinds of information.

The results of the survey showed that Type 1 and Type 2 Users from both Higher Education Institutions (HEI) gave the lowest rating to "Responsiveness" and "Competence" for the current system, respectively. However, with the proposed system, it was observed that all performance categories for Type 1 and Type 2 Users from both HEIs showed an increase in performance ratings as compared to the current system. Specifically, Responsiveness and Security obtained the highest ratings for Type 1 and Type 2 users from both HEIs, respectively. This just showed that users were more satisfied in the performance of the proposed system in addressing their concerns.

Table 0.1 Type 1 User Survey Results of the System

	HEI 1		HEI 2	
Categories	Current	Proposed	Current	Proposed
Responsiveness	2.6645	3.9021	2.6587	4.1198
Reliability	3.2619	3.6653	3.2111	3.8668
Competence	2.9444	3.5661	3.1138	3.9626
Communication	3.1111	3.7368	2.9588	4.0846
Convenience	2.8426	3.8730	2.9356	3.9042
Ease of Use	2.7011	3.8492	2.7176	3.8932
Security	2.7884	3.8413	3.1916	3.9012

Table 0.2 Type 2 User Survey Results of the System

	HEI 1		HEI 2	
Categories	Current	Proposed	Current	Proposed
Responsiveness	2.9000	3.4500	2.7500	3.7500
Reliability	2.9250	3.3500	2.9000	3.6500
Competence	2.5833	3.6667	2.3833	3.9667
Communication	3.1250	3.8000	2.5750	3.7250
Convenience	2.6167	3.7333	2.4833	4.0333
Ease of Use	2.8667	3.8167	2.7833	3.7333
Security	3.0250	3.8500	3.0000	4.1000

4. Conclusion

By using a customer-driven methodology, the researchers were able to come up with the proposed automated system that would satisfy the needs of the users. Criteria analysis aids in the selection of the best technology that will be used in the design of the Facility Management System. The evidence can be seen from the result of the test as they gave a higher rating to the proposed system. Furthermore, a comparison of the processing time of the same process was done to show the difference of the performance of the current and proposed system. It was proved that employing an automated system for such transactions provide faster service to its users

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