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Development of Chemical Management System for UTHM

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Abstract: University Tun Hussein Onn Malaysia (UTHM) Chemical Management System is the main platform for all chemical applications, registrations and handle all processes. The existing system records and manages all chemical information manually using a filing system. Next, all the chemical record is not centralized and is less accessible by the current administration as well as the manual filing may sometimes cause the Safety Data Sheets (SDS) to be missing. Therefore, a web-based UTHM Chemical Management System is developed using structured method. The system contains available chemical module, chemical application, chemical registration module, report generation module and supplier module. The Incremental Development Model is used as the methodology during the development of this system. This system has been developed to change the current system from manual into a web-based system as well as increase UTHM Occupational Safety, Health, and Environment (OSHE)'s accessibility to all chemicals' information. At the end of this project, UTHM Chemical Management System can switch from a manual to a web-based system.

Keywords: Management System, Chemical, Incremental Development Model

1. Introduction

Chemical is any basic substance that is produced by or using processes that involve changes to atoms or molecules [1]. The majority of the chemicals utilized in the lab are hazardous materials. A hazardous material is defined as some similar hazardous characteristics of the raw materials or chemicals or substances used [2]. Handling chemicals, such as the reaction, transport, storage, and disposal of chemicals, may be potentially harmful to human health and the environment. This is why chemicals should be managed properly. The importance of managing chemical solutions is to plan, control and coordinate the chemicals effectively.

UTHM OSHE is responsible for the matter that relates to Occupational Safety and Health, Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease

(NADOPOD), meeting management, and administrative affairs [3]. UTHM OSHE's Radiation and Chemical Unit acts as the designer and leader for the university community on hazard risk management connected to ionizing radiation and chemicals through compliance with national regulations [3]. The responsibility of this unit is to manage the collection, storage, packaging, re-labeling, and disposal of waste (chemical) twice a year [3].

Currently, the chemical management system in UTHM is done manually. Presently, UTHM OSHE's Radiation and Chemical Unit temporarily acts as the responsible unit for managing the process. However, the responsibility lies with the Chemical Management Centre that is expected to be formalized soon.

In the existing manual system, the chemical application form is submitted manually by a staff of a faculty or center referred as Pusat Tanggungjawab (PTj) to UTHM OSHE Radiation and Chemical Unit. The staff may require the use of certain chemicals either for teaching and learning purposes such as for lab activity or research purposes. Next, UTHM OSHE's Radiation and Chemical Unit will review the current chemical database to check the availability of the chemical in stock. If the chemical already exists, the application will be rejected, indicating that the applicant must use the existing chemical first until it either expires or depletes. If the chemical is not in the database, the application is approved. Afterward, the approved chemical is purchased from a certified supplier. UTHM Bursary performs purchasing of the chemical. After receiving the chemical along with the chemical's SDS, the applicants must register the chemical by submitting a registration form manually to UTHM OSHE's Radiation and Chemical Unit. Finally, the unit will add the chemical information into the existing chemical database.

An SDS provides comprehensive information about the chemical that allows employers and workers to obtain relevant, and accurate information that can be put in perspective concerning the hazards, uses, and risk management of the chemical product in the workplace [4]. Then, the current, temporary administration will record the chemical's life expectancy starting from the registration date and monitor the chemical's use until it is deemed expired after a year. Once the chemical is registered successfully, the current administration will review the chemical regularly.

In the existing system, all chemical information is recorded and managed manually using a manual filing system. This process takes a lot of time on a chemical application and subsequent registration. Besides that, all the chemical record is not centralized and is less accessible by the current administration. This is because each PTj retains its record which is maintained by the applicant and the lab assistant. Lastly, the manual filing may sometimes cause the SDS to be misplaced or missing from the file. This will lead to difficulty in obtaining the correct information regarding the resolution to a hazardous situation. Therefore, an online system and a database are required which can assist the current administration to conveniently manage all chemical registrations and improve the process efficiency.

UTHM Chemical Management System is a web-based system that replaces the existing manual system. This system was created to serve as the main platform for all chemical applications, registrations and handle all processes. There are two users involved in this system which are the current, temporary administration, UTHM OSHE's Radiation and Chemical Unit, and UTHM staff from any PTj who wants to apply for a chemical's purchase. The staff can range from Assistant Engineer, Lab Assistant, Science Officer, and lecturer for each PTJ. Meanwhile, the current administration can evaluate the application to allow the chemical to be purchased and subsequently registered the application. Applicants can also record and update chemicals registered in terms of quantity and expiry date. Applicants can view their registered chemical report too. Lastly, UTHM staff can maintain the chemical use information so that a monthly report of applications and registrations can be generated for the current administration along with active and expired chemicals reports.

There are three objectives for UTHM Chemical Management System. First objective is to design a Chemical Management System using a structured method. Next objective is to develop a

Chemical Management System using an incremental development model. Last objective is to evaluate the Chemical Management System using functional testing and user acceptance testing.

This paper contains five sections. Section 1 discusses the introduction of the project which include problem with the existing system and the project's objectives. The related work will be discussed in section 2. The project methodology will be described in section 3. Moreover, section 4 will explain the project's results and discussion. Lastly, conclusion will explain in section 5.

2.   Related Work

UTHM Chemical Management System is a web-based management system that will be a platform for all the chemical applications, registrations and manage all the processes. UTHM Chemical Management System is a management information system. Management Information System (MIS) offers untapped potential for business, industry, and government. There were some differences and similarities discovered after a study of existing related systems is conducted. Table 1 depicts a clear comparison between existing systems and the developed system.

Table 1 : Comparison between existing systems

Specifications	UTM Laboratory Information & Management System [5]	UNHCEMS® [6]	Data Sheet Solutions [7]	UTHM Chemical Management System
User Registration Module	No	No	No	Yes
Login Module	By using userId and password	By using username and password	By using email and password	By using email and password
Chemical Application Module	Yes	Yes	Yes	Yes
Status of application (Accepted or Rejected)	Yes	No	No	Yes
Chemical Registration Module	No	Yes	Yes	Yes
SDS submission	No	Yes	No	Yes
Report Generation Module	No	No	No	Yes
Web Servers	Not stated	Linux and Microsoft Windows PCs	Not stated	Windows

Based on the analysis, a few differences are observed. Firstly, only UTHM Chemical Management System has the user registration module. Next, UTM Laboratory Information & Management System uses user identification (ID) and password in the login module while UNHCEMS® uses username and password for login. Data Sheet Solutions and UTHM Chemical Management System using email and password for login purposes. All four systems have the chemical application module. Moreover, the status of the application can be viewed in UTM Laboratory Information & Management System and UTHM Chemical Management System, but UNHCEMS® and Data Sheet Solutions do not have that feature. Besides that, the registration module is not available in UTM Laboratory Information & Management System but in UNHCEMS®, Data Sheet Solutions and UTHM Chemical Management System. Next, SDS submission is unavailable in UTM Laboratory Information & Management System and Data Sheet Solutions, but UNHCEMS® and UTHM Chemical

Management System have it. By observation, the report generation module is unavailable in UTM Laboratory Information & Management System, UNHCEMS® and Data Sheet Solutions. Lastly, UNHCEMS® uses Linux and Microsoft Windows personal computers (PC) as the webserver. At the same time, UTM Laboratory Information & Management System's and Data Sheet Solutions web server were not stated and UTHM Chemical Management System uses a Microsoft Windows server.

3.   Methodology

This segment discusses the incremental development model. The Incremental development model is used during the development of the UTHM Chemical Management System. An incremental development model interspersed the tasks of definition, development, and validation [8]. The incremental development model starts with the requirement analysis phase which is the process through which the system's services, limitations, and goals are determined through consultation with system users [8]. The analysis and design is the second phase which assigns the requirements to either hardware or software systems and also establishes the system's general architecture [8]. Implementation is the third phase where software design is implemented as a set of programs or program modules at this phase [8]. Testing is intended to show that a program does what it is intended to do and to discover program defects before it is put into use [8]. Finally, the validation of the entire system phase will test the entire system to make sure whether it works as expected. Table 2 shows the system development task and deliverables for each phase in Incremental Development Model conducted in UTHM Chemical Management System.

Table 2 : System Development Task and Deliverable

Phases	Tasks	Output
Requirement Analysis	• Gather information on the chemical management system by interviewing the stakeholders. • Collect requirements on the components of the system. • Prepare a proposal for the system.	• System requirement document • Project Proposal • Gantt Chart
Increment 1		
Analysis & Design	• Collected requirements translated into a flow chart of the system. • Design context diagram, data flow diagram, an entity-relationship diagram for the system.	• Flow chart • Context diagram • Data flow diagram • Entity-relationship diagram
Implementation	• Construct the source code. • Develop the user registration module and login module.	• The initial prototype for the user registration and login module
Testing	• Perform functional testing for the user registration and login module. • Analyze the test result.	• Test plan for an initial version • Test cases for the initial version • Test results for the initial version

Table 2 : (continued)

Phases	Tasks	Output
Increment 2		
Analysis & Design	• A study on the initial prototype of the developed system will be conducted. • Develop the design of the system.	• The initial prototype of the system • Design of the system
Implementation	• Develop coding for the supplier, available chemical and chemical application modules.	• Intermediate version prototype
Testing	• Perform functional testing for the supplier, available chemical and chemical application modules. • Analyze the test result.	• Test plan for the intermediate version • Test cases for the intermediate version • Test results for the intermediate version
Increment 3		
Analysis & Design	• Develop the final version of the prototype. • Create a complete explanation of how the system works. • Make the latest user interface design.	• Latest user interface design • The final version of the prototype
Implementation	• Develop chemical registration and report generation modules.	• Completed final system
Testing	• Perform testing for chemical registration and report generation modules. • Analyze the test result.	• Test plan for the final version • Test cases for the final version • Test results for the final version
Validation	• Validate the functionality of the entire system. • Evaluate the performance of the system by releasing it to the users.	• Validated final system

4.   Results and Discussion

This segment discusses the system analysis and design.

4.1   Data Flow Diagram

A DFD is a fundamental artifact that must be developed for all systems in a structured approach [9]. A DFD depicts the processes, data stores, and external entities in an organization or other method and the data flow that connect them [9]. It features a hierarchical structure that allows for several levels of abstraction, which is important in system design. The context diagram depicts the complete business process as a single process, as well as the data flow to and from external entities [10]. Data stores are often not depicted on the context diagram. Figure 1 shows the context diagram of the UTHM Chemical Management System that is being developed.
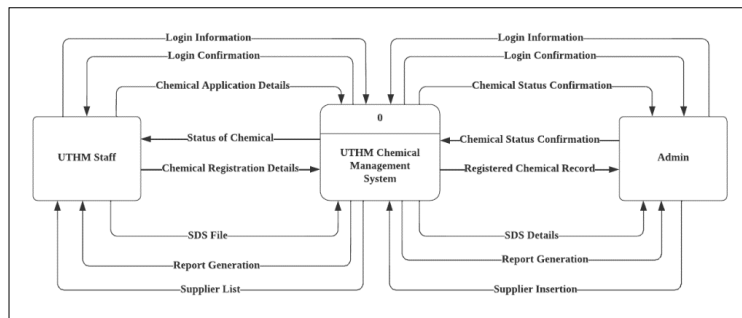
Figure 1 : Context Diagram

The next level of the DFD is level 0 which depicts a system's key processes, data flows, and data stores in greater depth [12]. Level 0 expands the context diagram into a lower-level diagram which is a level 0 DFD. DFD Level 0 depicts all operations at the initial level, including the numbers, data storage, external entities, and data flows between them. It is designed to view the Login process, Chemical Application process, Chemical Registration process, Chemical Report Generation process and Supplier process which is considered system single high-level process, with its relationship to external entities of UTHM staff and Admin. Figure 2 shows Data Flow Diagram Level 0 of the UTHM Chemical Management System.
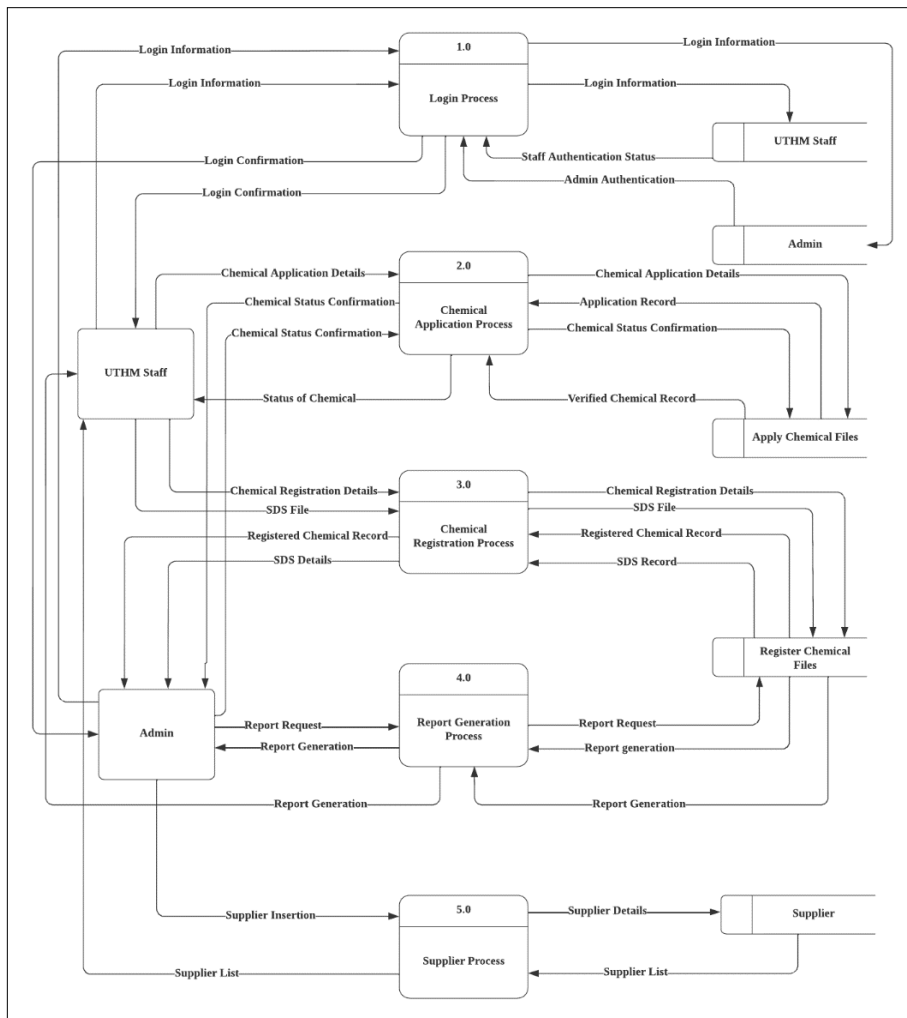

Figure 2 : Data Flow Diagram Level 0

4.2 Entity Relationship Diagram

The ERD is used to organize data and define the relationship between entities [11]. An ERD consists of three major components: entity, attribute, and relationship. An entity is anything actual or abstract that the developer wishes to retain data about. An entity is a person, place, event, or item significant to a particular system. Entities are classified into five types such as roles, events, classes, tangible things, or concepts. Aside from that, an attribute is a trait shared by all or most instances of a particular entity. A quality, feature, or characteristic of an entity, connection, or another attribute is referred to as an attribute [11]. Figure 3 shows the ERD for UTHM Chemical Management System.
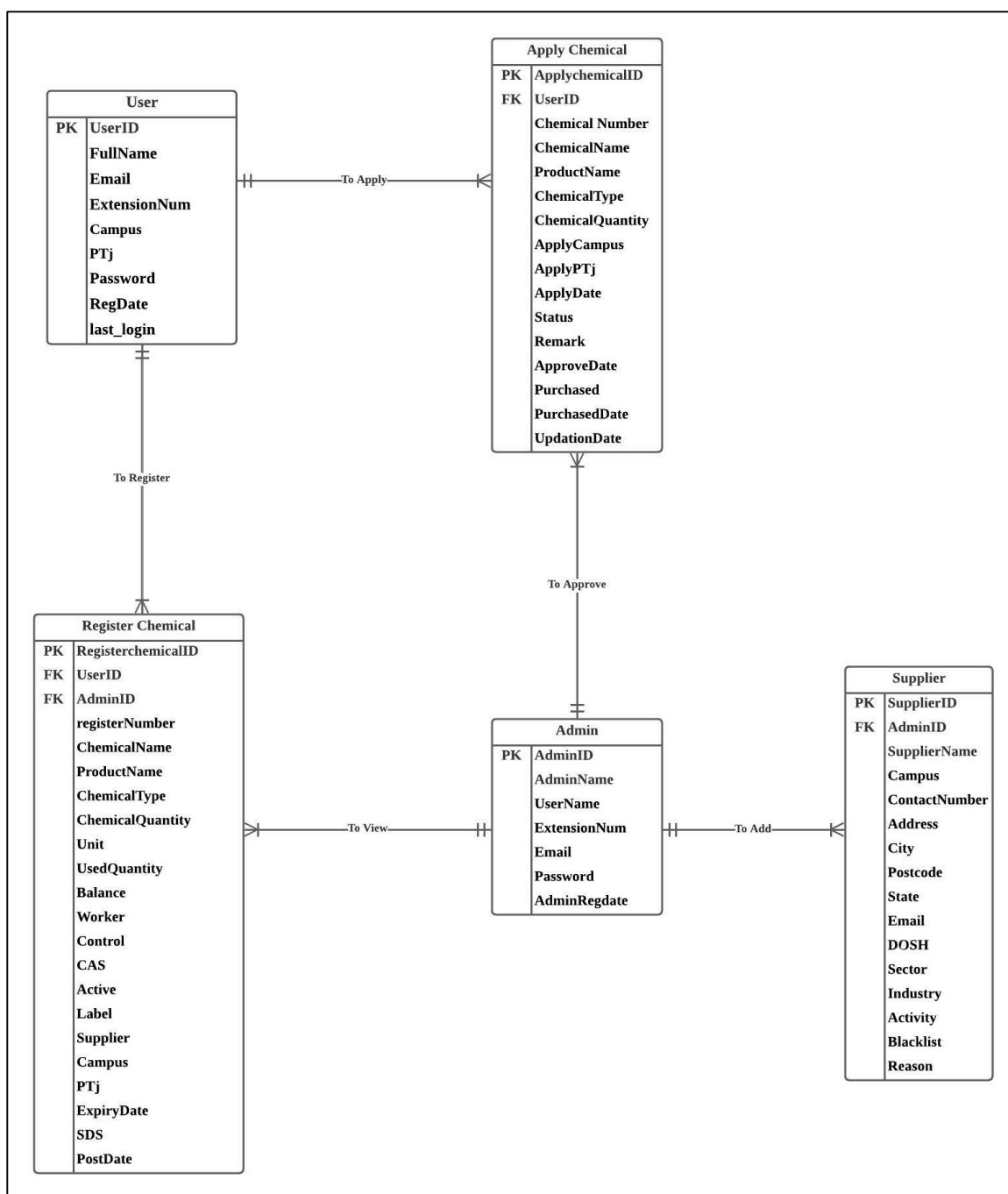

Figure 3 : Entity Relationship Diagram

4.3   System Flowchart

A flowchart displays the many stages of a process in sequential order. It is a comprehensive tool for defining various processes, such as a manufacturing process, an administrative or service process, or a project plan. There are two flowcharts for the UTHM Chemical Management System which are the flowchart of UTHM staff and the flowchart of admin. Figure 4 and 5 show the flow chart of UTHM staff and admin respectively.
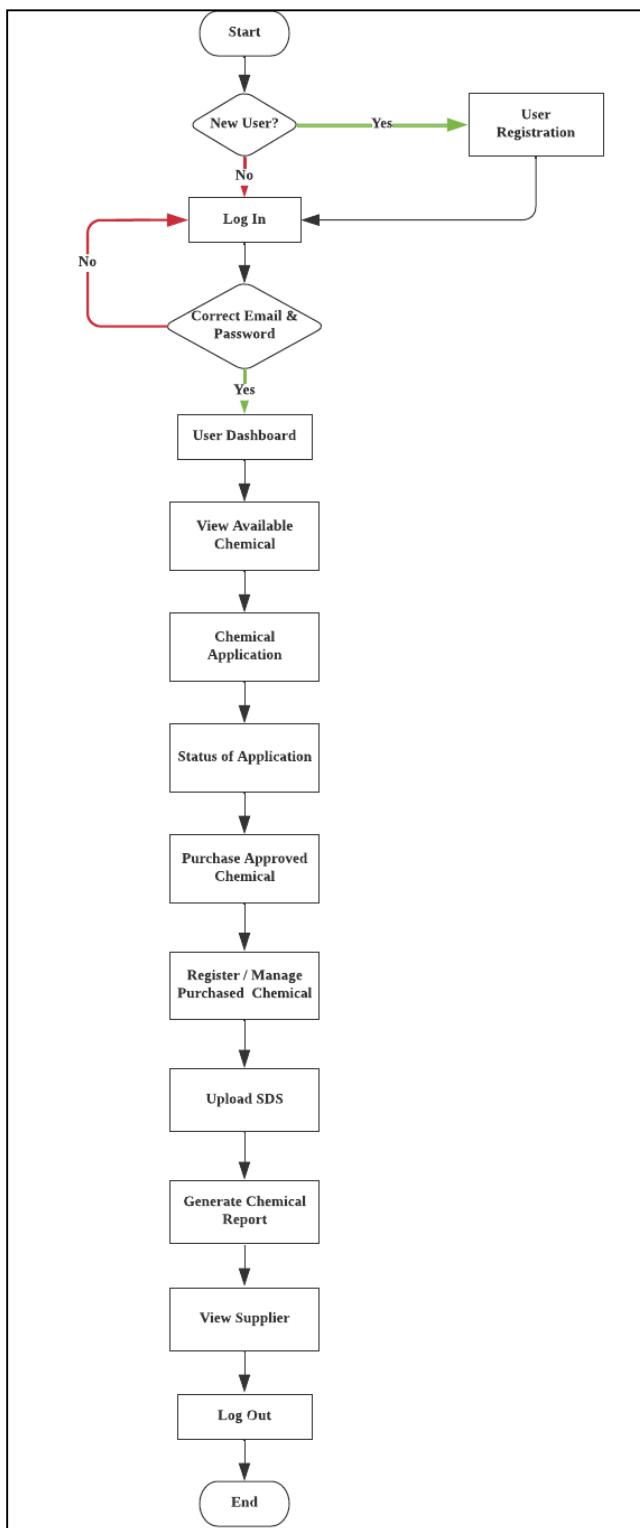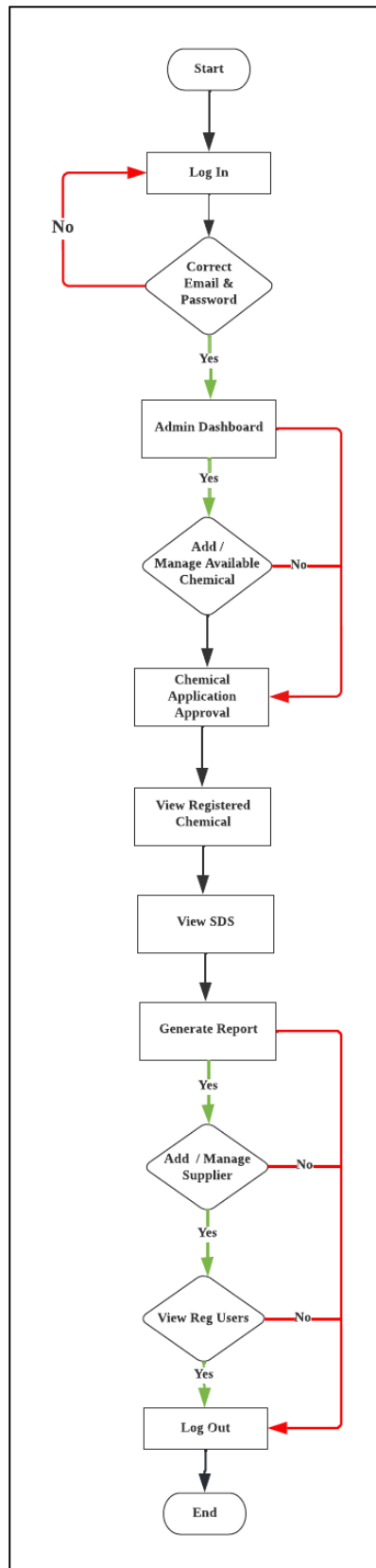

Figure 4 : Flow chart of UTHM staff

Figure 5 : Flow chart of Admin

4.1   Functional Testing

This segment discusses the system testing of UTHM Chemical Management System. There are two types of testing used which are functional testing and user acceptance testing. Functional testing is

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usually known as black-box testing whereby tests are derived from the system specification [8]. Typically, a test plan specifies what will be tested, the expected testing timeframe, and how tests will be documented. The following sections describe the test plans developed for functional testing. Table 3 shows the test plans conducted for UTHM staff, and table 4 shows the test plans worked for admin.

Table 3 : Test Plan for UTHM staff

No.	Test Cases	Expected Output	Actual Output
Login Module			
1	Enter the correct email and password	Login successful while redirecting to the dashboard	As expected
2	Enter the wrong email or wrong password	Appear a pop-up window with the message "Invalid details."	As expected
3	Enter either the email or password only	Appear a pop-up window with the message "Please fill out this field".	As expected
Available Chemical Page			
4	View the available chemical page	View the entire details of the available chemical with the available chemical quantity	As expected
5	Download the SDS file	Download the SDS file successfully	As expected
Chemical Application Module			
6	Insert all the required chemical details	Appear a pop-up window with the message "Chemical Application has been taken successfully".	As expected
7	Leave some fields blank with no information on it	Pop-out a window with the message "Please fill out this field".	As expected
8	Cancel the chemical application for the reason	A pop-up window appears with the message "Your application has been cancelled successfully".	As expected
9	Leave the reason field blank with no information on it	Pop-out a window with the message "Please fill out this field".	As expected
10	View the status of chemical application	View the status of each chemical application with the admin's remark	As expected
11	Change the status of purchase for the approved chemical.	Appear a pop-up window with the message "Purchase has been updated" and the status of purchase changes from "Chemical purchasing is pending" to "Chemical has been purchased".	As expected
Chemical Registration Module			
12	Insert all the required chemical details	A pop-up window appears with the message "Your registration has been taken successfully".	As expected
13	Leave some fields blank with no information on it	Pop-out a window with the message "Please fill out this field".	As expected
14	Insert the SDS not in jpg / jpeg/ png/pdf format	Pop-out a window with the message "SDS has Invalid format. Only jpg / jpeg /png /pdf format allowed".	As expected
15	Update the used quantity details	Pop-out a window with the message "Chemical details have been updated" and the available quantity is also updated automatically.	As expected
16	Delete the registered chemical.	Pop-out a window with the message "Do you really want to Delete?" and if yes, then the data will be deleted.	As expected

Table 3 : Test Plan for UTHM staff (continued)

No.	Test Cases	Expected Output	Actual Output
Report Generation Module			
17	View and print the registered chemical details	The report will be printed after the preview.	As expected
Supplier Module			
18	View the supplier details according to campus.	View the complete supplier details according to campus and their address and contact number.	As expected

Table 4 : Test Plan for Admin

No.	Test Cases	Expected Output	Actual Output
Login Module			
1	Enter the correct email and password	Login successful while redirecting to the dashboard	As expected
2	Enter the wrong email or wrong password	Appear a pop-up window with the message "Invalid details".	As expected
3	Enter either the email or password only	Appear a pop-up window with the message "Please fill out this field".	As expected
Available Chemical Page			
4	Insert all the required available chemical details	Appear a pop-up window with the message "Your registration has been taken successfully".	As expected
5	Leave some fields blank with no information on it	Pop-out a window with the message "Please fill out this field".	As expected
6	Insert the SDS not in jpg / jpeg/ png/pdf format	Pop-out a window with the message "SDS has Invalid format. Only jpg / jpeg /png /pdf format allowed".	As expected
7	Update the used quantity details	Pop-out a window with the message "Chemical details has been updated" and the available quantity is also updated automatically.	As expected
8	Delete the available chemical.	Pop-out a window with the message "Do you really want to Delete?" and if yes, then the data will be deleted.	As expected
Chemical Application Module			
9	View the details of the applied chemical.	View the complete chemical information along with their extension number and email address.	As expected
10	Change the status of chemical application.	A pop-up window appears with the message "Status has been updated," along with the remark.	As expected
11	View the user cancel the chemical application	View user cancels chemical application with the reason for cancellation.	As expected
12	View the status of chemical purchase	View the status of purchase for all approved chemicals.	As expected
Chemical Registration Module			
13	View the registered chemical details	View the entire details of the registered chemical with the available chemical quantity	As expected
14	Download the SDS file	Download the SDS file successfully	As expected

Table 4 : Test Plan for Admin (continued)

	Report Generation Module		
15	Insert the "from date" to "to date" to view the applications and registration chemicals report.	The report will be printed successfully after preview.	As expected
16	View and print the active and expired chemicals details.	The report will be printed after the preview.	As expected
	Supplier Module		
17	Insert all the required supplier details	Appear a pop-up window with the message "Supplier detail has been added".	As expected
18	Leave some fields blank with no information on it	Pop-out a window with the message "Please fill out this field".	As expected
19	Update the supplier details according to campus	Pop-out a window with the message "Supplier details has been updated".	As expected

4.2 User Acceptance Testing

During user acceptance testing, a target user formally evaluates a system to determine whether or not it should be approved by the system supplier or whether more development is needed [8]. Responses were analyzed in a bar chart to make the analysis process easier. The questionnaire was given and filled out by 4 UTHM OSHE staff. There are 2 sections, perceived usefulness and perceived ease of use, including 14 questions in the questionnaire, which are displayed. These criteria are determined by a scale of 1 to 5, where 1 strongly disagrees, 2 disagrees, neutral scale is 3, 4 agrees scale and lastly 5 strongly agrees.

Figure 6 shows the bar chart of the first question of Section Perceived Usefulness which sounds like the system is helping to accomplish tasks more quickly. 50% of respondents strongly agreed that the developed system helps to complete tasks more quickly, while another 50% partially agreed.
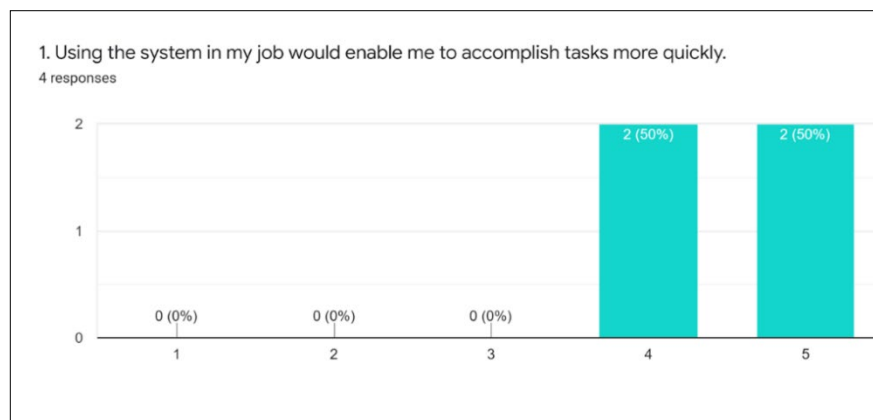

Figure 6 : Bar chart of the first question

Figure 7 shows the bar chart for the second question where the system would improve my job performance. 50% of respondents strongly agreed that it improved their job performance. In comparison, another 50% partially agreed with it.
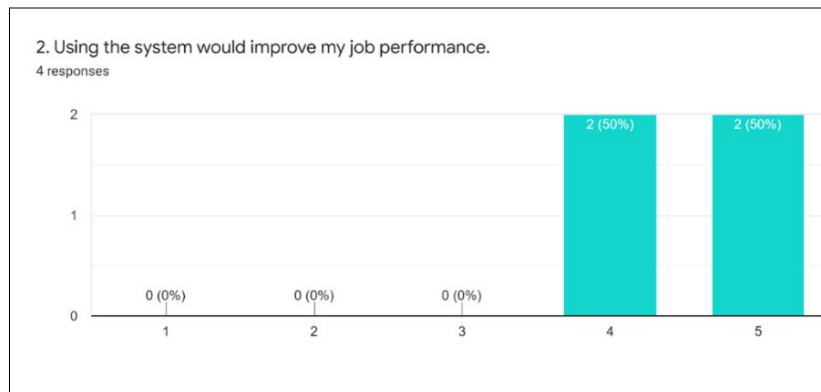

Figure 7 : Bar chart for the second question

Figure 8 shows the third question of the questionnaire. 75% of respondents agreed that the system would increase their productivity. However, 25% of respondents partially agreed.
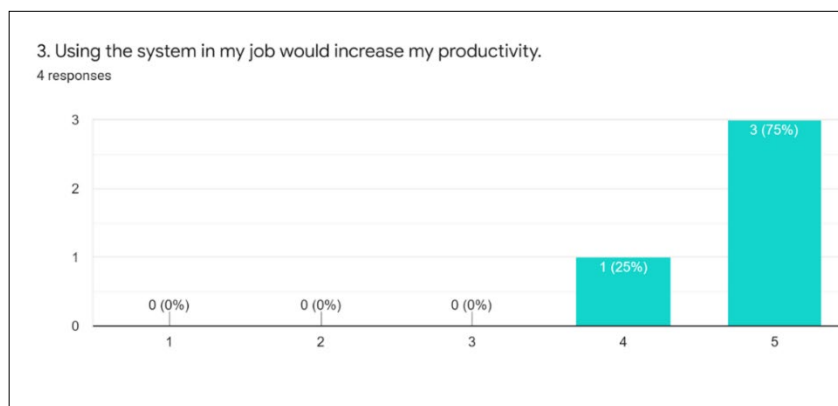

Figure 8 : Bar chart of the third question

Figure 9 shows the bar chart of the fourth question about enhancing the effectiveness on the job. The respondents strongly agreed with the statement that the system will improve their job effectiveness.
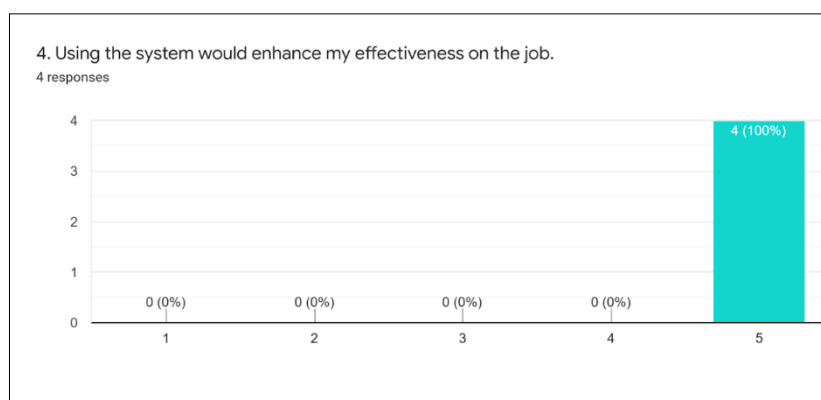
Figure 9 : Bar chart of fourth question

Figure 10 shows the bar chart of the fifth question, which is about the UTHM Chemical Management System can make their job easier. 75% of respondents strongly agreed with the statement. In comparison, 25% of respondents voted for partially agreed.
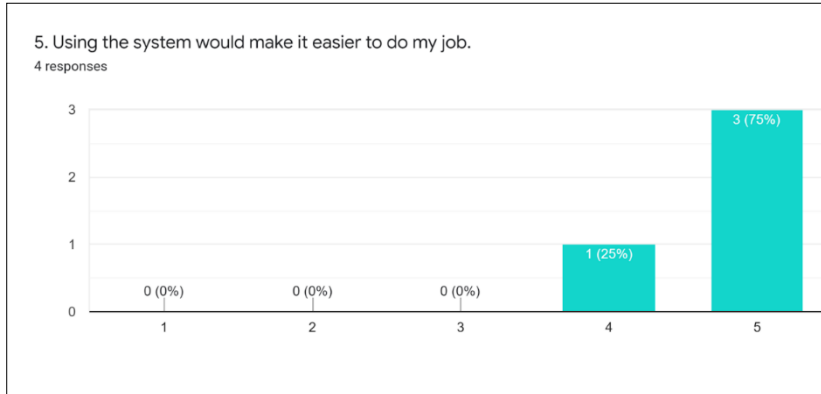

Figure 10 : Bar chart of the fifth question

Figure 11 shows the bar chart of the sixth question in the questionnaire. 75% of respondents voted strongly agreed that the system is useful in their job, while another 25% voted for agreed.
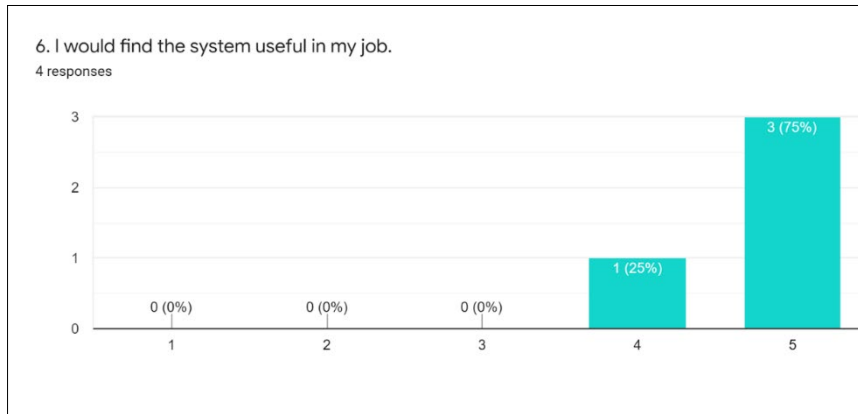

Figure 11 : Bar chart of the sixth question

Figure 12 shows the bar chart of the seventh question on how learning to operate the system would be easy. Half of the respondents strongly agreed that the system could be easily understood while another half partially agreed with the statement.
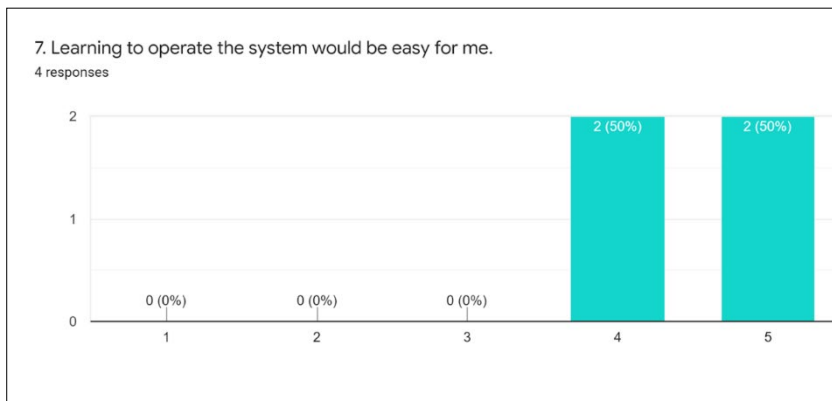

Figure 12 : Bar chart of the seventh question

Figure 13 shows the bar chart of the eighth question which sounds like the respondent finds it easy to get the system to do what they wanted. 50% of the respondents strongly agreed while another half agreed with the statement.
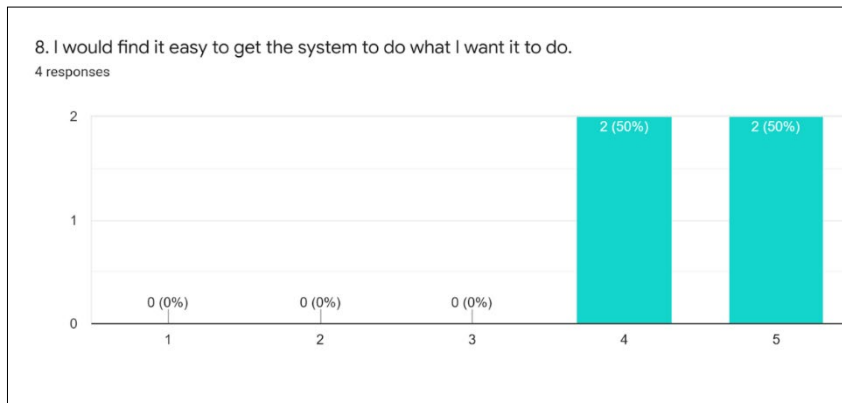

Figure 13 : Bar chart of the eighth question

Figure 14 shows the bar chart of the ninth question about whether the system would be clear and understood by users or not. 50% of respondents strongly agreed that the system is clear and easily understood, while another 50% of respondents voted for agreed.
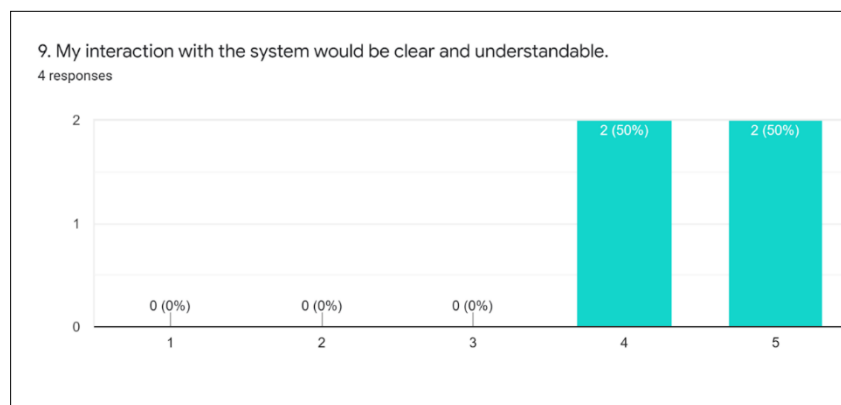

Figure 14 : Bar chart of the ninth question

Figure 15 shows the bar chart of the tenth question of the questionnaire. Half of the respondents strongly agreed that the system is flexible to interact with. However, another 50% of respondents agreed with the statement.
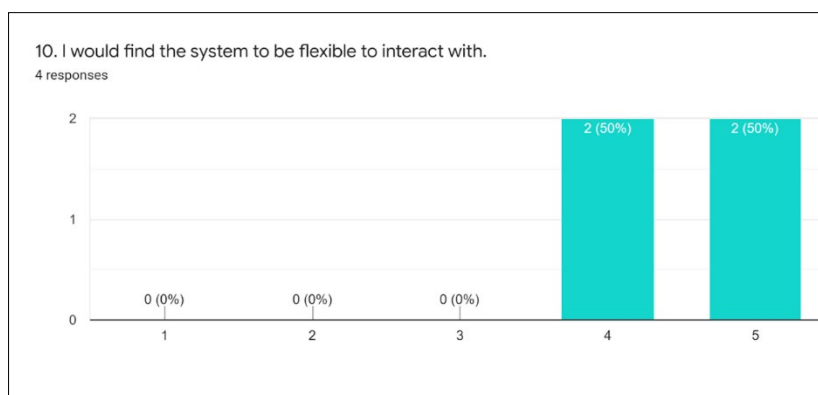

Figure 15 : Bar chart of the tenth question

Figure 16 shows the eleventh question which indicates that the system would easily become more skillful in using the system. Half of the respondents strongly agreed and another half just agreed with the statement.
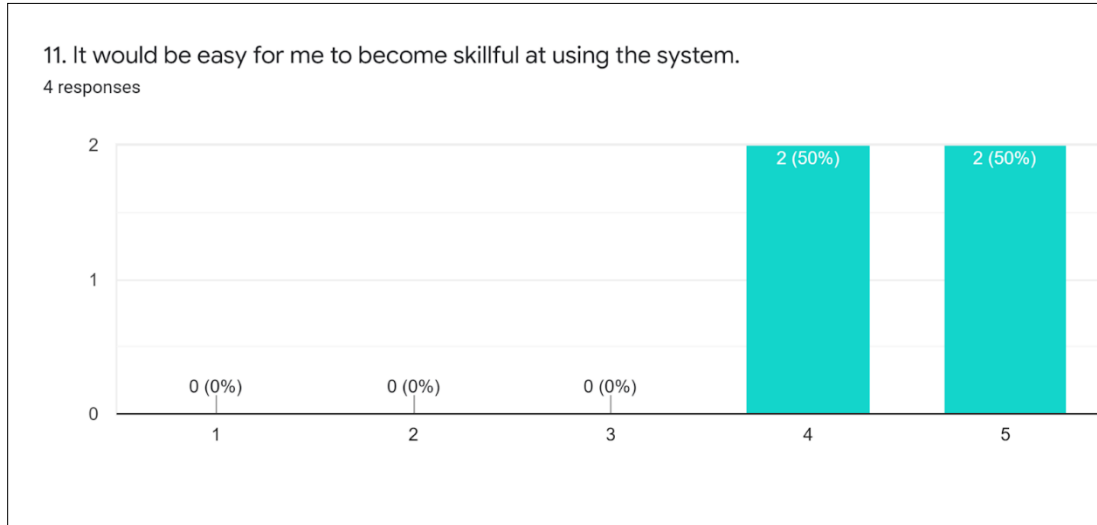

Figure 16 : Bar chart of the eleventh question

Figure 17 shows the bar chart of the twelfth question of the questionnaire. 75% of respondents strongly agreed that the system is easy to use while 30% agreed with the question.
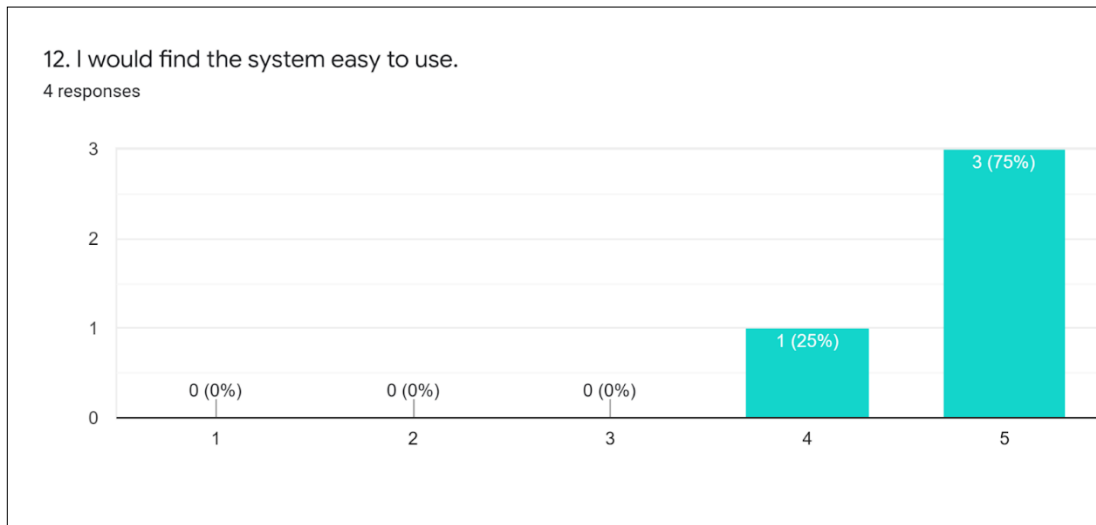

Figure 17 : Bar chart of twelfth question

For question 13, 3 respondents answered the question which asking the respondents to list the negative aspects. Firstly, a respondent told to improve the system for user-friendly. One of the respondents also listed that the chemical purchasing needs to be more user-friendly, the application can be done for more than one chemical in an application and also set a notification to use email to update their registration at least once a month. Lastly, there is also a suggestion from the respondent to use the dropdown menu in most of the entries if possible.

For question 14, the respondents were asked to list the most positive aspects of the developed system. The respondent's answers were good system application for CMC, very nice design and easy to use, the layout is easy, and the system covers most of the requirements. This indicates that the developed system has been met the most of the user requirements

5. Conclusion

In a nutshell, UTHM Chemical Management System has been successfully developed using Visual Studio Code and Xampp which aims to serve as the main platform for all chemical applications and registrations and handle all processes. The first objective which is to design a Chemical Management System using a structured method is successfully achieved. The second objective to develop a Chemical Management System using an incremental development model also successfully achieved. The third objective to evaluate the system using functional and user acceptance testing is also completed.

During the process of analysis and development of the UTHM Chemical Management System, several limitations are recognized. Firstly, this system does not enable UTHM staff to modify the details of applications after the chemicals are applied. Secondly, the system does not deliver any email information to the applicants regarding the status of the chemical applications that have been made. Hence, the applicants need to log in to the system every time to verify their application progress. Besides that, the system also does not provide a notification to users to update their registration details at least once a month. Last, the application module does not enable UTHM staff to apply more chemicals in one application.

Few future works can be done to UTHM Chemical Management System to improve the efficiency and functionality. First and foremost, the system can provide UTHM staff the ability to manage application information after an application has been submitted. Besides that, it is also possible that the system might improve functionality, such as the ability to send out notifications. Notification alerts may also remind users to update their registration information at least once a month, if not more often. Finally, there can be the ability to add additional chemicals in a single application.

Acknowledgment

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