Designing a Question Bank Management System to Support Outcome-Based Education Approach

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Summary
University that implements Outcome-based Education (OBE) focuses on outcomes such as the achievements of students that are measurable, proven and can be improved. Thus, the curriculums are driven by the learning outcomes (LO) and the students' assessments are very essential to achieve the learning and Students Outcome. One of the student assessment methods is examination that required to be developed by the instructors in every semester. Developing quality test items for each specific LO are not an easy task that requires lots of time, energy and resources. Many instructors face difficulties to prepare quality quizzes, exams and tests which lead to the administration of examinations for each semester has become increasingly laborious, time consuming and costly. Hence, a question bank is developed purposely to support the OBE process; specifically for examination assessment by storing, managing and maintaining the question items. The designing of this question bank is applying the concept of map that allows the items to be stored and manage hierarchically from general to specific items. The items are constructed based on Bloom Taxonomy that classifies the LOs into levels of complexity and specificity. The methodology is adopting the object oriented software development using Unified Modeling Language that consists of analysis, design, implementation and testing. The result of this study is a question bank that the user requirements have been tested by the end user in acceptance testing. Although this question bank is developed purposely for CCSE, the usage of it shall be extended to any institutions that adopt OBE to support the examination assessment method. This study has significantly contributes to the higher level education process, specifically for OBE process as well as to the software engineering body of knowledge.

Key words:
Outcome-based Education, Question bank management system, Bloom Taxonomy, Concept of map, Object oriented software development

1. Introduction

In these days, there has been significant increasing the students' population in many institutions [1]. As the number of students' growth, the task of administering assessment in Outcome-based education (OBE) such as developing items for suitable Learning Outcome (LO), maintaining the item quality for every LO and conducting tests and examinations become tedious and laborious. Furthermore, the administrative processes of assessment and evaluation can become a nightmare for some institutions [2]. The same issues are faced by University of Jeddah, especially at the College of Computer Science and Engineering (CCSE) that the numbers of students are increasing, which lead to the administration of examinations for each semester has become increasingly laborious, time consuming and costly.

The CCSE is adopting the OBE whereby the curriculum are driven by the LO and the students' assessment are very essential to achieve the LO and Students Outcome (SO). Thus, developing quality test items for each specific LO are not an easy task that requires lots of time, energy and resources. In addition, the availability of small number of quality test items may lead to reuse these test items in several examination which the students can guess or know the answers before they are tested, making achievement tests result does not match their actual knowledge [3].

Many instructors face difficulties to prepare quizzes, exams and tests. Questions are constructed based on high values course learning outcomes (HVCLO) that have been specified in course specification file. In the course specification, there are course learning outcomes (CLO) and the essential CLO are given priority as HVCLO. Most of the instructors work in isolation and each of them build up questions that are saved solely on his/ her hard disk. Furthermore, sometimes those questions are got lost due to several of reasons such as hard disk crash, bugs in software or file lost. Creating new questions are complex and the instructors require long time to develop new questions. It is hard to construct new questions and time wasting to measure the degree of percentage for questions based on HVCLO. In addition, the instructor moves from course to another every semester. The instructor for current semester takes longer time to find the instructor for previous semester for handover or knowing what to do. The sharing of knowledge and information usually is neglected, which makes more difficult in course administration. Hence, a question bank management

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system is proposed, which aims to help CCSE's instructors to compose questions examination paper according to specific HVCLO and SO set in the course specification file and assessment entries.

The objective of this study is to develop a question bank management system that intended to support OBE exclusively for assessment via test, quiz and examination. This question bank facilitates two important theoretical frameworks which are:

The items are constructed to measure the specific CLO or HVCLO using the Bloom's taxonomy [4], [5] that has six different level of cognitive domain from simple to complex. Thus, the items are having different level of difficulties to measure the CLO/HVCLO.

i. The items are stored and bale to be displayed systematically from general to specific topic by expediting the concept of map [6] to enhance the knowledge structure. Hence, the structure of the test bank is well defined for easy storing, searching and management.

Some of the benefits of this question bank are:

- To reduce the amount of time in preparing examination paper, and emphasis should be given to assign each question with suitable HVCLO using the bloom taxonomy
- To improve the quality of examination paper by assigning each question with suitable HVCLO that needs to be achieved by the course.
- To maintain and administer the questions effortlessly by storing and accessing the questions using the concept of map

The scope of this study is for the users who are instructors and administrator at CCSE, University of Jeddah that adopting the ODE in education system. Fig. 1 below depicts the system context of this study.

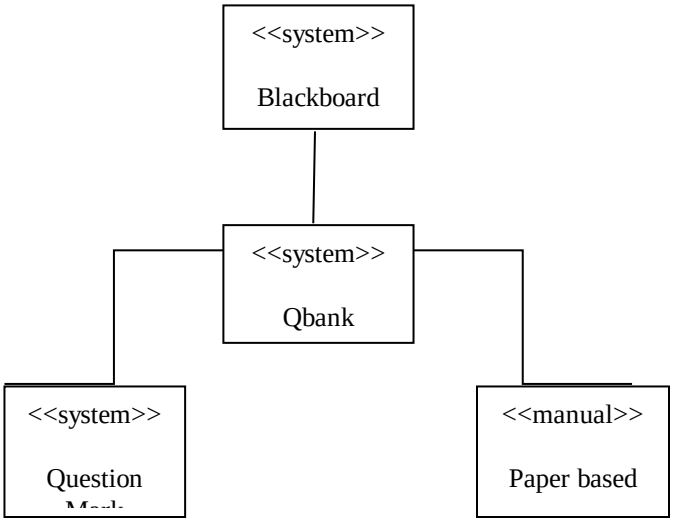

Fig. 1 System Context

2. Background

2.1 Outcome-based education

Over decades, Outcome-based education (OBE) has been adopted in education system at multiple levels around the world, for instance at Australia [7], South Africa [8], United States [9], Hong Kong [10] and Malaysia [11]. OBE is an approach to education system whereby curriculums are motivated by the learning outcomes (LO) that the students acquire at the end of the course [12]. The OBE approach is different from other educational approach as it concerns on preparing the students for long life learning after graduating from program. The OBE concentrates on what the students learn from the course, how to help the students learn it and able to explicate what was taught in the course undoubtedly. In order to assess the OBE, several assessment methods are selected to measure to which extend the students have learnt from the course. One of the most important assessments is examination that needs to be developed to measure the required LO.

2.2 Question bank management system

Assessment is a continuous systematic process that inferences about learning and development of students. It is a process of defining, selecting, designing, collecting, analyzing, interpreting and using information to increase students' learning and development [13]. One of the assessment methods is examination or test that aims to measure the students' knowledge based on the LO. Examinations have been chosen as assessment methods to assess student learning by the end of the course [14]. Moreover, examinations are crucial for the academic teacher and learning process as well as to the school or university's administration procedures [15]. It can be seen from the school or university's perspective that examination aims is to gauge their students' ability and competitiveness. On the other hand, for the students, the examinations give them goals and pushing them to attain that goal in the specific time. As for the teacher or university lecturer, the examinations results provide them the learning outcome curves that allow them for improvement in the future towards better learning process. Designing and preparation of the examination is a repetitive task and a very tedious process that includes (a) developing the exam, (b) digitizing it with text editor such as Microsoft Word, (c) piloting and reviewing the quality of each question, and finally, (d) printing out the exam papers [16]. Hence, there is a necessity to store and

manage these examinations systematically using question bank.

A question bank also known as item bank is defined as a relatively large collection with the number of items exceeds by several times the number to be used in any one test of easily accessible test questions; that the items are indexed, structured, or otherwise assigned information that can be used to facilitate their selection [17]. The question bank is a management system that assists the users to store, manage and search the question items for different examinations or test procedures according to needs as all the items are organized systematically. The question bank management system is able to provide more beneficial functions to support the organizational mission and vision.

2.3 Theoretical Framework

2.3.1 Concept of maps

Concept maps have been used for many years as a tool for people of all ages and all domains of knowledge to express their understanding about a topic. The concept maps were developed in 1972 by researchers at Cornell University for representing conceptual knowledge structures [6], [18], [19]. There are many qualitative and quantitative studies that researchers have shown that concept maps can promote meaningful learning, which leads to positive effects on students [20], [21].
In education domain, concept maps have been revealed as a successful tool for teachers to assess students' understanding, whether at the beginning, during, or end of the study of a topic [19]. This is because the concept maps can also be a visualized cognitive tool that helps students organize their knowledge and learning experiences, so that their self-awareness can be improved through reflective thinking [22].

2.3.2 Bloom's Taxonomy of Learning Domains

Bloom and his colleagues established the most widespread classifications in formulating, identifying objectives and the classification divides the objectives into three areas [4], [5]:

- Cognitive domain
- Affective domain
- Psychomotor domain

Bloom was interested in dividing the cognitive domain, and gave most of his attention to other spheres, which is where we will focus. It concentrates on capacity or mental processes that relate to knowledge of facts, the operations of understanding and remembering, and discovering methods of identifying information and building concepts, principles, and generalizations [4]. Benjamin Bloom divided this area into six graded levels, from simple to complex, as shown in Fig. 1.

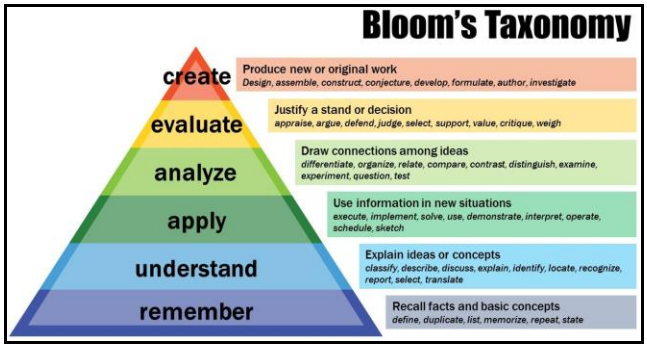

Fig. 2 Bloom's Taxonomy of Cognitive Goals[4], [5]

2.4 Related Work

OUM Qbank [1] is a test management system developed by Open University Malaysia to support the online distance learning. OUM QBank was designed with the main objective of reducing the laborious manual process of examination or test items preparation and administration and to ensure the quality of examination papers prepared.
Learning Outcome-based Question Examination paper Tool (LoQET) [23] is proposed as a tool for assisting lecturer in Universiti Putra Malaysia for preparing examination paper based on programme outcomes and learning outcomes set in the teaching plan and assessment entries.
Question bank in Moodle [24] is a feature allows a teacher to create, preview, and edit questions in a database of question categories. The categories can be limited to being used on the site, course or quiz level. The questions in a category can be added to a quiz or to a lesson activity via an export process. The teacher enters the question bank by creating or editing a quiz activity or via Course administration > Question bank.
WebAssign [25] is a service was developed, launched, and is hosted at North Carolina State University. WebAssign's core function is to load end-of-chapter questions from various textbooks into its archives, from which instructors may pick and choose in order to assemble a virtual assignment.

2.4.1 Comparison among several question banks.

This section describes the comparison among several available question banks based on their features as shown in Table 1 below.

Table 1: Features comparison

Features	OUM Qbank [1]	LoQET [23]	Question bank in Moodle [24]	WebAssign [25]	CCSE Qbank
Store and manage the items based on concept of map	X	X	X	X	√
Items construction based on LO	X	√	X	X	√
Items construction based on different level of difficulty based on Bloom's Taxonomy	X	X	X	X	√
Generate examination paper	√	√	X	X	√
Reuse the items	√	√	√	√	√
Systematic Storage Structure	√	√	√	√	√
Item Analyses based on LO	X	X	X	X	√
Support OBE	X	√	X	X	√

3. Methodology

The methodology for this project is designed purposely to achieve the project objective so the phases involve are analysis, design, implementation and testing.

3.1 Analysis

In this phase, we conducted the requirements elicitation and requirements analysis using Unified Modeling Language.

3.1.1 Requirements elicitation

The requirements are elicited via online survey using a set of questionnaire that was prepared for instructors who are one of the main users for our application. The questionnaire was created using SurveyMonkey website [26] and been distributed through group massages to reach instructors in CCSE. The sample of respondent was 20. The survey focused on collecting data about the current practice of how the instructors develop the questions and what are the features that they would like the question bank to have in order to help them in questions development.

A. Functional Requirements

The functional requirements describe what the system should do. In other words, functional requirements describe system behavior under specific conditions [27]. The requirements of the application and the actors are as following:

- The user (instructor and administrator) can log in and log out
- Allow the instructor to select the course
- Allow the instructor to manage the course.
- Allow the instructor to construct question based on HVCLO.CLO and Bloom's Taxonomy
- Allow the instructor to manage questions
- Allow the instructor to display question from general to specific questions
- Allow the instructor to develop exam paper
- Allow the instructor to manage exam paper
- Allow the instructor to generate exam questions
- Allow instructor to search questions
- Allow the instructor to generate exam analysis report
- Allow the administrator to create instructor profile
- Allow the administrator to manage instructor profile
- Allow the administrator to assign instructor to course.
- Allow the administrator to manage instructor to course assignment
- Allow the administrator to create course
- Allow the administrator to manage course
- Allow the administrator to create HVCLO/CLO

for each course
- Allow the administrator to manage HVCLO/CLO for each course

B. Non-functional Requirements

Non-functional requirements describe how the system works. In other words, describe how a system must behave and what constraints there are on its functionality [27]. The essential non-functional requirements in the following:

- Performance: Fast response time, when the user makes application loading, and refresh time.
- Accessibility: Makes user able to navigate between pages easily by provides button in each page.
- Ergonomic: intended to provide comfort by making it does not required user efforts while using.
- Simplicity: Should provide the user interface easy to understand.

3.1.2 Interaction models

Interaction models are important to show the interactions of user interaction, which involves user inputs and outputs; interaction between the software being developed and other systems in its environment; or interaction between the components of a software system [28]. Thus, interactions models consist of use case diagram and sequence diagrams.

A. Use case diagram

A Use Case diagram is used to show what system functions are performed for which actor [28], [29]. It describes the functionality of a system from the perspective of users in the system [27], [30]. The use case diagram for this study is illustrated below in Fig. 3. The use case specification is a document used to capture the specific details of a use case [27]–[30]. Every use case is described extensively in use case specification and there are 19 use case specifications all together in this study.

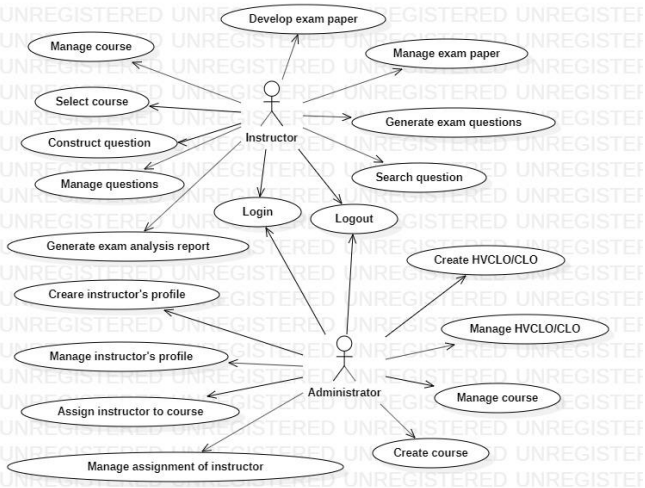

Fig. 3 The use case diagram

B. Sequence diagrams

Sequence diagrams are primarily used to model the interactions between the actors and the objects in a system and the interactions between the objects themselves [28]. Specifically, a sequence diagram shows the sequence of interactions that take place during a particular use case or use case instance [29]. In this study, the sequence diagrams are developed for every basic flow, additional flows and alternative flows in a use specification. Thus, there are 36 sequence diagrams for this study.

3.1.3 Structural models

Structural models of software display the organization of a system in terms of the components that make up that system and their relationships [28]. In this study, a class diagrams is used for modeling the static structure of the object classes in a software system. The classes are group into three stereotypes, which are boundary classes, control classes and entity classes. The boundary classes encapsulate interaction with external actors (users or external systems); control classes allow the processing required for the execution of a use-case and its business logic, and coordinates, sequences controls other objects involved in the use-case and entity classes for represents persistent information relevant for the stakeholders [27], [28], [31].

3.1.4 Structural models

Behavioral models are used to describe the dynamic behavior of an executing system. This behavior can be modeled from the perspective of the data processed by the system or by the events that stimulate responses from a

system [28], [29]. Activity diagrams may be used to model the processing of data, where each activity represents one process step [28]. Thus, for this study, there are 19 activity diagrams to show the activity in each use cases. Fig. 4 below shows the activity diagram for instructor to create question.

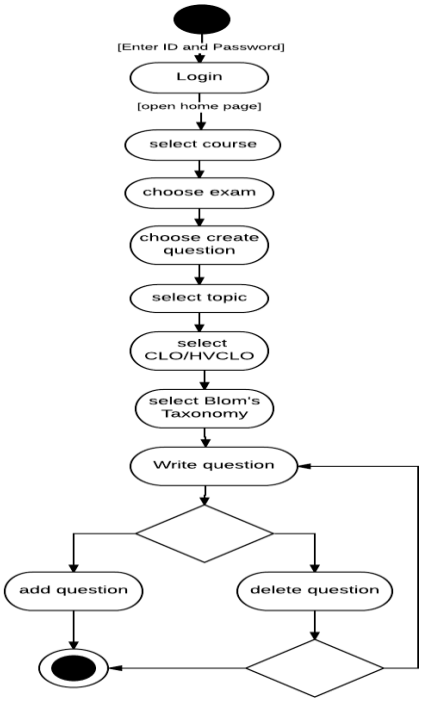

Fig. 4 Activity diagram for instructor creates question.

3.2 Design

Design is a phase to show the objects or object classes in a system. It also shows the associations and relationships between these entities. These models are the bridge between the system requirements and the implementation of a system [28]. Thus, there are structural models; behavioral modes and user interface design are developed in the design phase.

3.2.1 Structural models

The structural models describe the static structure of the system using object classes and their relationships [28]. Thus, the class diagram in the analysis phase is updated by adding the important relationships that may be documented at this stage are generalization (inheritance) relationships, uses/used-by relationships, and composition relationships.

3.2.2 Behavioral models

Behavioral models describe the dynamic structure of the system and show the expected runtime interactions between the system objects [28]. In this study, sequence diagrams from the analysis phase are updated by converting the object to class and messages passing between the object to operations that calling from one class to another class.

3.2.3 Database design

The database design is focusing of designing the entity classes by using the entity relationship diagram (ERD) as shown in Fig. 5. In this ERD diagram, the data are design to apply the concept of map. The concept of map is represented in a hierarchical structure whereby the item that most general concept goes on top and the more specific concept goes to the bottom.

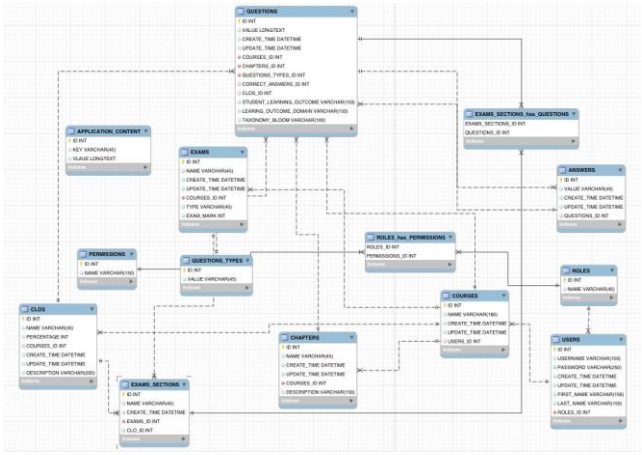

Fig. 5 The entity relationship diagram

3.2.4 User interface design

User interface design creates an effective communication medium between a human and a computer [27]. In this phase, a prototype that consist of user interfaces are developed following a set of interface design principles, design identifies interface objects and actions and then creates a screen layout that forms the basis for a user interface prototype. Fig. 6 shows the user interface for the prototype.

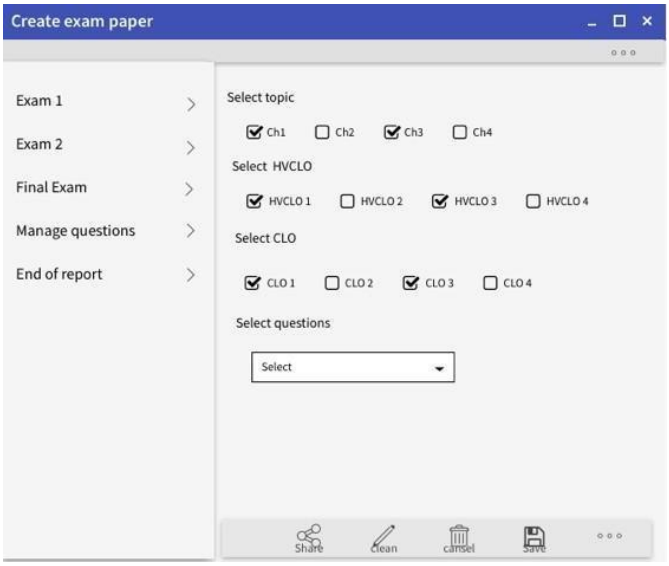

Fig. 6 User interface for creating the exam paper

3.3 Implementation

In the implementation phase, the question bank is developed using the NetBeans 8.2 using Primefaces [32] and database is developed using MySQL Workbench [33]. The main interface for the lecturer is shown in the Fig. 7 and Fig. 8 shows how the instructor can create question.

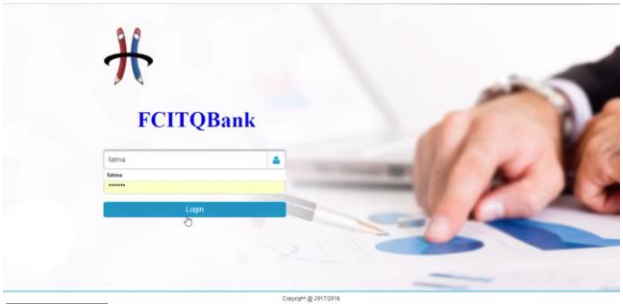

Fig. 7 The main page for the instructor

Fig. 8 Instructor can create questions

3.4 Testing

In testing phase, there are three type of testing were conducted. The first testing is development testing which has three stages of testing which are unit testing, component testing and system testing [28], [34]. The second testing is known as black box testing which is focusing on testing software from the user perspective to test the functional requirements [35]. The third testing is user testing that aims to ensure that the question bank actually meets the user needs and acceptance.

3.4.1 Development testing

The development testing includes all testing activities that are carried out by the team developing the system [36]. The tester of the software is usually the programmer who developed that software [34]. There three stages of development testing which are unit, component and system testing.

A. Unit testing

In unit testing, every individual program units or object classes are tested. Unit testing focus on testing the functionality of objects or methods [37]. During the testing object classes, we design our tests to provide coverage of all of the features of the object. This means that we test all operations associated with the object; set and check the value of all attributes associated with the object; and put the object into all possible states. This means that we simulated all events that cause a state change.

B. Component testing

In component testing, where several individual units are integrated to create composite components [38]. Component testing should focus on testing the component interfaces that provide access to the component functions [28].In this component testing, we identify and access the functionality of these objects through component interfaces. We tested the composite components and focus on showing that the component interfaces or interfaces behaves according to its specification. .

C. System testing

In system testing, where some or all of the components in a system are integrated and the system is tested as a whole [28]. System testing during development involves integrating components to create a version of the system and then testing the integrated system. Thus, we checked that components are compatible, interact correctly, and

transfer the right data at the right time across their interfaces.

3.4.2 Black box testing Method

In the black box testing, the functional testing is chosen to test the functional requirements. Thus, the following steps are carried out [35] :

- The functional requirements and specifications of the system are examined.
- Tester chooses valid inputs (positive test scenario) to check whether the application can processes them correctly. Also, some invalid inputs (negative test scenario) are chosen to verify that the application is able to detect them.
- The software tester determines expected outputs for all those inputs.
- The software tester constructs test cases with the selected inputs.
- The test cases are executed.
- Software tester compares the actual outputs with the expected outputs.
- Defects if any are fixed and re-tested.

3.4.3 User testing

User or customer testing is a stage in the testing process in which users or customers provide input and advice on system testing [28]. For this user testing, we conducted the alpha testing, where a selected group of software users (instructors and administrator) work closely with the development team to test early releases of the software. This means that the users can identify problems and issues that are not readily apparent to the development testing team. The developers can work from the requirements, but these often do not reflect other factors that affect the practical use of the software [28], [29]. Users can therefore provide information about practice that helps with the design of more realistic tests.

4. Result and discussion

4.1 Data analysis

This section describes the data analysis and result of this study. We have conducted an online survey particularly to understand the needs and opinions for this question bank from the instructors' perspective. In this survey the respondents are 20 active instructors. Fig. 9 shows the time that the instructor takes time to create a question. Most of the instructors with 45% claimed that they took less than 30 minutes to create a question.

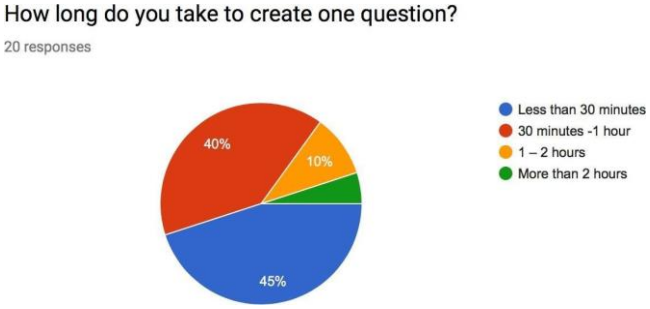

Fig. 9 Time taken to create a question

Fig. 10 below shows the time that instructor spent to create an exam paper. It is shown that 45% of the instructors spent 3 to 5 hours to construct an exam paper.

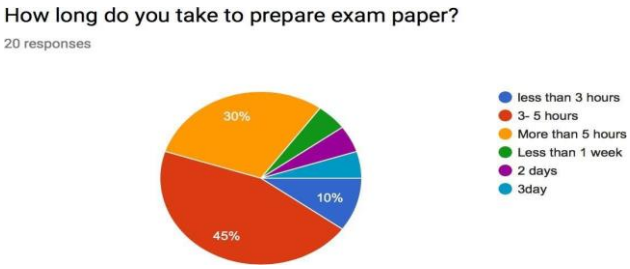

Fig. 10 The duration taken for preparing an examination paper

Fig. 11 below shows that media that most of the instructors keep their questions on hardisk or on cloud using Google Drive.

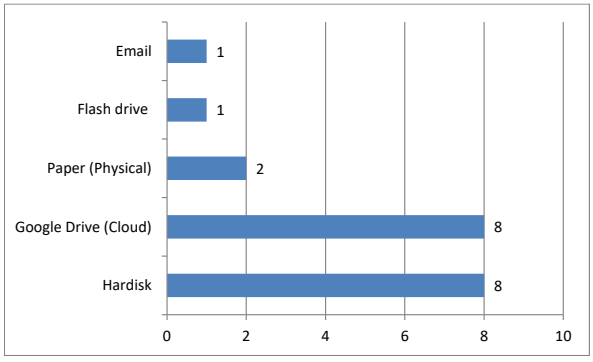

Fig. 11 The media used to keep the questions

Table 2 below shows the current practice in constructing questions and it can be concluded that

- Most of the instructors reuse their questions when they develop the examination paper.
- 50% of the instructors select questions from any

website.

- Most of the instructors keep their questions and 14 respondents stated that they keep their questions more than 2 years.
- Most of the instructor would like to use a question bank if they have the opportunity.
- Most of the instructors (14 respondents) claimed that they never use any question bank before.

Table 2: The current practice in constructing questions

No	Questions	No of responses		
		Yes	No	Not sure
1	Do you reuse your questions in preparing the examination paper?	17	2	1
2	Do you select questions from any website?	10	9	1
3	Currently, do you keep your questions? If the answer is YES, Less than 1 year = 2 1-2 years = 2 More than 2 years = 14	18	0	2
4	If you are given an opportunity to use a question back in preparing your examination paper, would you like to use it?	16	0	4
5	Do you have any experience in using any question bank before?	6	14	0

In this survey, we are very insist to know what are functions that the instructors wish to have in order to encourage them to use the question bank. Hence, the Table 3 below shows the result and it can be determined that the question bank should allow the instructor to:

- create questions based on HVCLO/CLO
- reuse any questions in the question bank
- manage my questions (Add, Delete, Edit, Display)
- change another questions and make it as my question without changing the original questions.
- make changes to my questions
- create questions based on different level of difficulties based on Bloom Taxonomy
- search any question
- generate the examination paper based selected HVCLO/CLO
- generate an exam analysis report that can show details of every questions level of difficulties and HVCLO/CLO

Table 3: The required question bank's functionality

No	Question	No of responses				
		gly	Agr	ve	utr	sa
1	I can create questions based on HVCLO/CLO	18	2	0	0	0
2	I can reuse any questions in the question bank	15	2	0	3	0
3	I can manage my questions (Add, Delete, Edit, Display)	15	5	0	0	0
4	I can change another questions and make it as my question without changing the original questions.	14	1	0	5	0
5	I am allow to make changes to my questions	20	0	0	0	0
6	I can create questions based on different level of difficulties based on Bloom Taxonomy	18	2	0	0	0
7	I can search any question	17	3	0	0	0
8	I can generate the examination paper based selected HVCLO/CLO	16	4	0	0	0
9	I can generate an exam analysis report that can show details of every questions level of difficulties and HVCLO/CLO.	18	2	0	0	0

4.2 Result

The result of this study is a question bank management system that intended to support OBE and provide assistance to instructors during constructing the questions during examination paper development. Among the interfaces of the questions bank are shown below in Fig. 12.

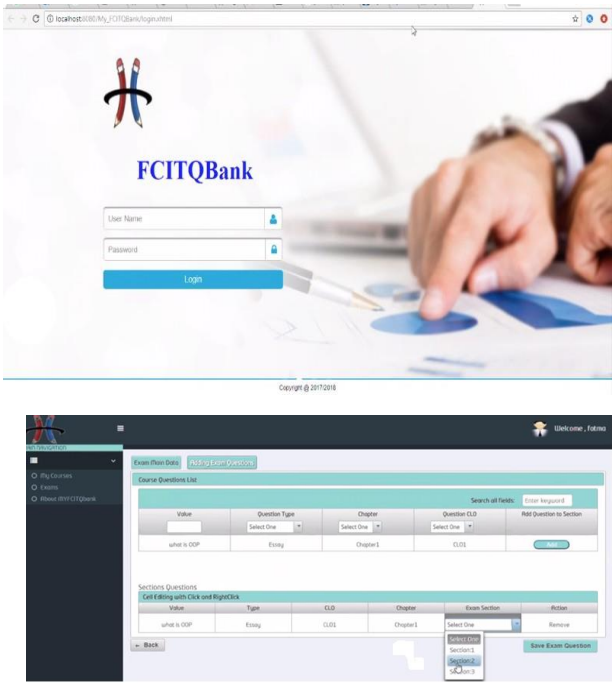

Fig. 12 Sequences of interfaces

Table 4: The acceptance testing report

No	Acceptance Requirements	Critical		Test result		Comment
		Yes	No	Accept	Reject	
14	The instructor able to construct question based on HVCLO/CLO and Bloom's Taxonomy	√		√		
15	The instructor able to construct question in the same topic from general to specific (concept of map)	√		√		
16	The instructor able to develop exam paper	√		√		
17	The instructor able to manage exam paper	√		√		
18	The instructor able to generate exam questions	√		√		
19	The instructor able to search questions	√		√		Searching based on topic
20	The instructor able to generate exam analysis report based on HVCL/CLO	√		√		This function will only activate after instructor completes generating exam paper

21	The instructor able to display the questions from general to specific	√		√		This function facilitate concept of map

No	Acceptance Requirements	Critical		Test result		Comment
		Yes	No	Accept	Reject	
1	The administrator able to create instructor profile	√		√		
2	The administrator able to manage instructor profile	√		√		
3	The administrator able to assign instructor to course	√		√		
4	The administrator able to manage instructor to course assignment	√		√		
5	The administrator able to create course	√		√		
6	The administrator able to manage course	√		√		
7	The administrator able to create HVCLO/CLO for each course	√		√		
8	The administrator able to manage HVCLO/CLO for each course	√		√		
9	The user (instructor and administrator) able to log in and log out	√		√		
10	The instructor able to select the course	√		√		
11	The instructor able to manage the course	√		√		
12	The instructor able to construct question	√		√		
13	The instructor able to manage questions	√		√		

The Table 4 above shows the acceptance testing that was conducted to determine whether or not the question bank satisfies the acceptance criteria for the user to accept this question bank. The result as indicated that the end user has successfully accepted the question bank based on the stated requirements.

5. Conclusion

This question bank is developed purposely to support the OBE process at CCSE specifically for examination assessment by storing, managing and maintaining the question items. The development of this question bank is applying the concept of map that allows the items to be stored and manage hierarchically from general to specific items. The items are constructed based on Bloom Taxonomy that classifies the HVCLO/CLO into levels of complexity and specificity.

The limitations of this study are:

- The question bank is capable of generating examination papers on demand; however the question bank needs to have sufficient items deposited into the database. This is to avoid a high probability of repeated items that can reduce the examination quality.
- The quality of items that are deposited into the question bank is very much dependent on the instructors' expertise and skills in constructing quality items.
- This question bank support OBE process for examination assessment only in order to confirm

that every item in the examination is measuring the chosen LO.

In the future, this question bank shall be enhanced by integrating the artificial intelligent features for applying the concept of map, embedding the algorithm that able to perform traversal and searching in the maps. In addition, the examination paper that is generated from this question bank should be able to export to text editing software, for example Microsoft words for preparing the examination paper.

As a conclusion, although this question bank is developed purposely for CCSE, the usage of it shall be extended to any institutions that adopt OBE to support the examination assessment method. This study has significantly contributes to the higher level education process, specifically for OBE process as well as to the software engineering body of knowledge.

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