

A College-Wide Assessment Management System in an Integrated Medical Curriculum

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ABSTRACT

The objective of this research is to design and develop an online college-wide assessment management system for medical schools. This involves relational database design as well as user process flow design. These two design charts were developed with careful consideration of user requirements. The system has been used for over 400 assessments in less than three years. An integrated curriculum can benefit from an assessment management system by creating a growing question bank and delivering assessments electronically. Specifically by collecting and storing tagged questions, delivering assessments, collating and disseminating results including question psychometrics, giving feedback to learners, giving feedback to question writers, and finally by collecting tags (metadata) for each question which allows for comparison of grouped questions (e.g. by theme) and automatically generating assessments based on selected metadata criteria. Both learners and teachers can benefit from such a system by getting proper feedback on performance. Medical educators as well can benefit by optimizing both managerial and educational aspects of assessments. Keeping in mind that information gathering and interaction with eventual users is vital to the accurate and appropriate design of the system, it is possible to develop a secure online assessment management system for medical schools which satisfies the needs of assessment management and delivery and is earnestly used and accepted.

Keywords: Medical school, assessment, design and development, online assessment system.

1. INTRODUCTION

In an integrated curriculum such as the one at the College of Medicine and Health Sciences (CMHS), United Arab Emirates University (UAEU), each course is taught by multiple instructors from several disciplines. Each instructor is responsible for his/her own sessions in the course as well as documentation of session summaries, objectives, resources, and creation of assessment questions. The medical curriculum at CMHS is six years with around 5,000 sessions (lectures, practicals, and clinical encounters) in total.

Because of this integrated teaching of medical curricula, there is no software or online system available to manage assessments. The College found itself in need of a management system to perform this vital task and has opted to develop its own assessment management system to meet the needs of creating a college-wide question bank for all levels of the curriculum, criterion-based assessment creation, delivery of assessments, and reporting of results and examination analyses.

2. BACKGROUND

For several years now the UAEU has been using an eLearning platform (Blackboard) for delivering learning content to students. While Blackboard satisfies the content delivery end of an electronic curriculum and is well suited for university courses, CMHS has a need to manage the assessments in a different way because its course structures are different from typical university courses.

Most university courses have one instructor exclusively in charge of several students. They meet several times a week at set times for the whole semester spanning around four months. This instructor is responsible for taking attendance, writing and conducting assessments, as well as all other matters pertaining to the course. For the most part, eLearning systems are designed based on this course model.

At CMHS, however, there is an inherently different course model because of the integrated nature of the curriculum in a medical school. Each course at CMHS has many instructors (around 10-20). One of them is the coordinator who takes care of preparing the course timetable, collecting exam questions from the instructors, among other course management duties. The coordinator needs to have the ability to collect questions in a secure manner and then create, deliver, and analyze examinations, while the instructors need to follow the usage of their own questions only.

The medical curriculum at CMHS is six years long with a total of around 50 courses. Each course will typically have three assessments which involve Multiple Choice Questions (MCQs): A short quiz (or two), a midterm exam, and a final exam. Per year, the college will conduct around 150 MCQ-type

examinations for students in all six years of study. These examinations range from short quizzes and midterm exams (10-30 questions) to course final exams (60-80 questions) to two-year program comprehensive examinations (100-120 questions).

3. METHODS

The process of development and implementation of the CMHS Assessment Management System (AMS) in terms of requirements analysis, relational database design and process flow design has been discussed previously when developing the Curriculum Management System (CMS) as it is the same process [1]. The system uses ASP as the programming language that performs all the processing, JavaScript for data entry checking, AJAX to refresh information on parts of the webpage and MS SQL Server as the Relational Database Management System used to store all the data pertaining to the assessments. Dynamic web pages for input and output were developed to be clear, consistent and user-friendly.

Finally, user control was taken into account, giving each user access to allowed information and processes only. As a result of the needs analysis, it became clear that both the delivery as well as the creation and management of assessments are important. In addition, several items in the CMS were deemed necessary for managing assessments such as learner lists, assessment breakdown, assessment session date and time, and attendance record to decide on learner eligibility to take assessments.

Because of the sensitive nature of assessments several security measures were put in place including: Placing the system on its own secure web server with access from within the College only, using the University's secure internet protocol key (https) to access the website, allowing access from specific on-campus computer only, and limiting access to specific users.

4. RESULTS

Needs analysis for the users of this system, who are administrators, medical educators, course coordinators, teaching faculty, and medical students, produced the following needs list based on the three main parts of the system:

1. Assessment Creation:

- Faculty:
 - a. Use the CMS to get a prompt for questions (get exam dates from CMS)
 - b. Notify faculty on pending question submission deadline
 - c. Allow faculty to edit unused questions and add new questions
 - d. Allow faculty to view their questions and usage statistics
 - e. Allow faculty to add tags to the questions (metadata) such as difficulty level, Bloom's taxonomy, etc.
 - f. Allow faculty to link course or session objectives to questions
- Department Chairs:
 - a. Allow department chairs to vet questions authored by their faculty

- Coordinators:
 - a. Use the CMS to prompt for questions (get exam dates from CMS)
 - b. Notify coordinator on completion level of question submission
 - c. Allow coordinator to generate exam from Question Bank by providing criteria (i.e. new vs used, difficulty level, Bloom's taxonomy, etc)
 - Directors:
 - a. Allow directors to vet exam papers by viewing metadata statistics
2. Assessment Delivery:
- All MCQ assessments delivered to students electronically
 - Reliable, secure, and easy to use electronic system for delivery
 - Coordinator in control of assessment:
 - a. Assigning exam password
 - b. Setting scrambled questions and pre-scrambling
 - c. Opening and closing examination
 - d. Monitoring student progress during examination
3. Assessment Analysis:
- Question Analysis (Percent Correct and Point Biserial)
 - Coordinator can grade assessment and generate analysis
 - Directors can view assessment grades and analysis
 - Directors/Coordinators can remove "bad" questions
 - Faculty can view question analysis for their questions
 - Coordinator can release marks to students

A suitable Entity Relationship Diagram (ERD) was developed using the results of the needs analysis and relational database theory (partially shown in Figure 1).

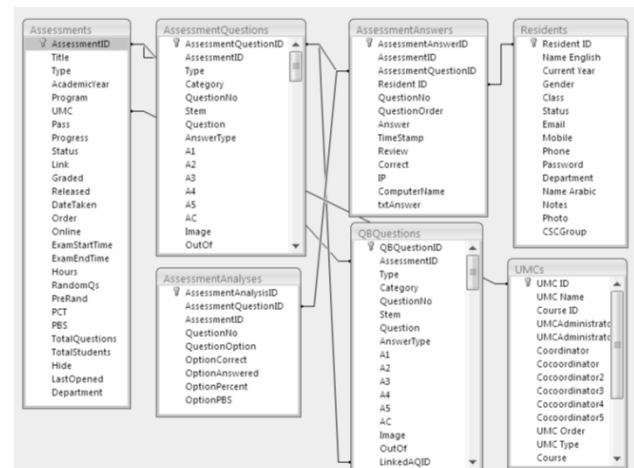


Figure 1. Partial Database Entity Relationship Diagram.

The ERD included several related tables: Assessments, Assessment Questions, Assessment Answers, Assessment Analyses, Question Bank, Courses, and Students. The process flow diagram included process flows for several users: Students, Faculty, Coordinators, and Administrators. The database-driven website model was used to develop the system using MS SQL for storing and querying data, ASP as the web programming language, JavaScript for data entry checking, and AJAX for seamless page refreshing. Several online forms and pages were developed to accommodate input and output processes.

A suitable Process Flow Diagram (PFD) was also developed (partially shown in Figure 2).

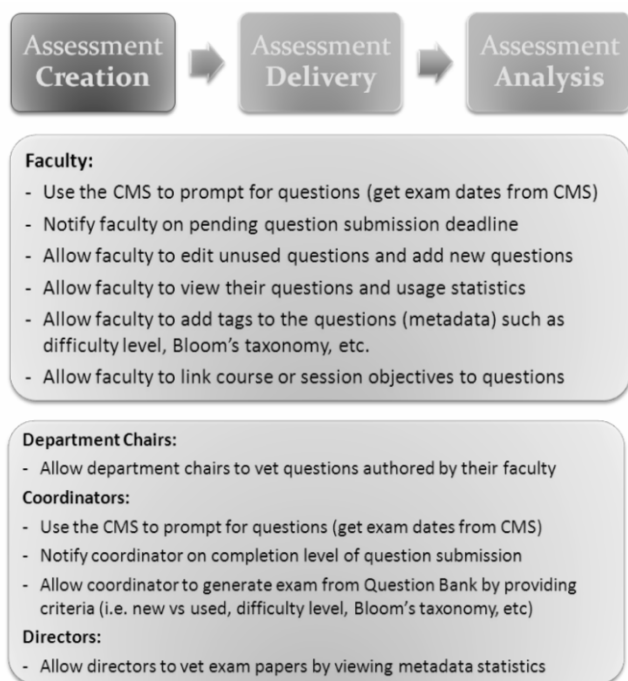


Figure 2. Partial User Process Flow Diagram.

Because security is a big concern for such a system, the developed user Process Flow Diagram is essential for guiding the developer to clearly implement user access control and allow users to view, edit, and process only the information in which they have privileges.

The system includes a Question Bank in which users can view and edit their questions as well as track question usage (Figure 3). A snapshot of a question metadata (tags) being edited is in Figure 4 and of the question breakdown of one of the examinations is in Figure 5.

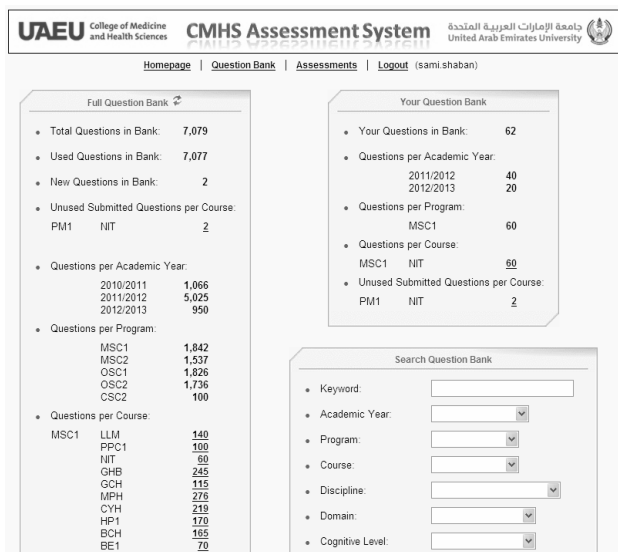


Figure 3. Snapshot of the Question Bank Homepage.

Discipline 1	Mathematics
Discipline 2	
Discipline 3	
Domain 1	09 Foundation
Domain 2	
Domain 3	
Cognitive Level (Bloom's Taxonomy)	1 Knowledge
Question Type	Problem Solving
Medical Function	Not Applicable
Body System1	Not Applicable
Body System2	
Body System3	
Difficulty Level	1 Very Easy
Examinee Level	Pre-Medical
Target Course	NIT
Target Exam	Final Exam

Figure 4. Snapshot of question metadata (tags) being edited.

Number of Questions by Discipline1	Removed Questions	Average Mark (Before Removal)
Pathophysiology	15 (50.0%)	0
Pharmacology	6 (20.0%)	0
Internal Medicine	3 (10.0%)	0
Pathology	2 (6.7%)	0
Radiology	2 (6.7%)	0
Community Medicine	2 (6.7%)	0

Number of Questions by Theme	Removed Questions	Average Mark (Before Removal)
Respiratory	28 (93.3%)	0
Pulmonary	2 (6.7%)	0

Number of Questions by CognitiveLevel	Removed Questions	Average Mark (Before Removal)
1 Knowledge	14 (46.7%)	0
2 Comprehension	9 (30.0%)	0
5 Synthesis	7 (23.3%)	0

Number of Questions by DifficultyLevelPCT	Removed Questions	Average Mark (Before Removal)
1 Very Easy (90-100)	11 (36.7%)	0
2 Easy (70-89)	11 (36.7%)	0
3 Average (31-69)	8 (26.7%)	0

Number of Questions by QuestionQualityPBS	Removed Questions	Average Mark (Before Removal)
1 Good (0.20-1.00)	24 (80.0%)	0
2 Average (0.01-0.20)	4 (13.3%)	0
3 Poor (-1.00-0.00)	2 (6.7%)	0

Figure 5. Snapshot of the question breakdown of one of the examinations.

Based on these requirements analysis, a secure system was developed for collecting and storing tagged questions (with metadata), delivering assessments, collating and disseminating results, giving feedback to learners, giving feedback to question writers, comparing grouped questions (e.g. by theme), and automatically generating assessments based on selected criteria.

Over 400 assessments of the Multiple Choice Question (MCQ) variety have been delivered during the last three years. Currently there are over 15,000 unique MCQ questions in the bank assessing all levels of the medical curriculum which have been developed by CMHS faculty members for the most part. These questions have been delivered to learners in examinations and

are stored in the system along with their tags and psychometric data. Nearly a million learner/questions have been delivered by the system while logging over 5 million clicks by examinees using this system.

5. DISCUSSION

The main parts of the CMHS AMS are:

- Collecting and storing tagged questions (with metadata)
- Delivering assessments
- Collating and disseminating results
- Giving feedback to students
- Giving feedback to question writers
- Compare grouped questions (e.g. by Theme)
- Automatically generate assessments based on criteria

This system focuses on the electronic management and delivery of MCQ assessments which facilitates the College's continuous improvement endeavors to develop, manage and report data related to the quality of student assessments. It is premised on a college-wide shared responsibility for effective management and delivery of assessments which, in contrast to different assessment instruments, is given surprisingly little attention in the literature [2].

The value (or weight) of each question is considered equal for all questions at this point but the system is designed to make adjustments to this weighting if needed. The weight of each exam is set depending on the amount of content covered (e.g. quiz, midterm exam, final exam, etc). We currently have 15,000 questions developed in-house as mentioned and we are always looking to add validated questions from external banks. Questions are linked to learning objectives in an ad hoc manner at the moment. We require that each faculty member submit questions about their teaching sessions. The teaching sessions are linked to objectives but more rigorous linkage is needed and is underway. Throughout higher education, more emphasis is being placed on outcomes and enabling objectives that faculty are seeking to promote [3] and our faculty are well acquainted with reasons for and principles of aligning assessments with learning objectives [4]. Once complete, we will have questions linked to objectives in a clear manner.

Several other types of assessments are also used in the curriculum such as essays, reports, simulated patient clinical scenarios, etc. but at the moment this project only focuses on MCQ-type assessments. The system is nevertheless adaptable to inclusion of other forms of assessment used in medical education and which is compatible with a programmatic approach to assessment advocated by medical educators [5,6]. Future work in this area will report on procedures supporting a programmatic approach. MCQ-type questions comprise of around 80% of the final course mark in the early years of study lowered to around 40% of the mark in the later years.

Due to ease of standardization, objective testing of large groups and ability to sample a broad range of knowledge, MCQs are widely used for both formative and summative assessment in undergraduate medical education [7]. A major challenge of MCQs however, is they are often poorly written in ways that test recall of independent facts rather than application of knowledge. Well-constructed MCQs can however, test higher order cognitive skills such as application, evaluation, synthesis,

integration and judgment of medical information [7]. The tagging of our MCQs (required metadata in the system) provides a very useful mechanism for faculty and course directors to identify the level of Bloom's Taxonomy that questions address, among other important educational constructs such as level of difficulty [8].

There is a wealth of real-time data being collected during assessments. This "big data" [9] is generated by nearly a million learner/questions which have been delivered by the system while logging over 5 million clicks by examinees using this system. Several medical education research ideas have been triggered in electronic assessment by this data such as examinee behavior patterns during assessments (time spend on questions, frequency and benefit of changing answers during assessments, etc.) and making judgments on the appropriate length of assessments in terms of time and number of questions.

Because of the key fact that in our medical curriculum many teachers teach in one course, both central and distributed management of the assessments are important. Making available customized views and processes for each user type is crucial to the success of the system in achieving its intended goals. These views and processes must be made available with the correct level of information and the appropriate access rights depending on who the user is. For example, students should only be able to view assessments when they are open and view their results when they are released whereas faculty members should be able to enter questions into the bank and track their usage. Coordinators should be able to collect questions in a secure manner and then create, deliver, and analyze examinations.

6. CONCLUSION

An integrated curriculum can benefit from an assessment management system by maintaining a question bank and creating and delivering assessments electronically. Specifically by collecting and storing tagged questions, delivering assessments, collating and disseminating results including question psychometrics, giving feedback to learners, giving feedback to question writers, and finally by collecting tags (metadata) for each question which allows for comparison of grouped questions (e.g. by theme) and automatically generating assessments based on selected criteria. Both learners and teachers can benefit from such a system by getting proper feedback on performance. Medical educators as well can benefit by optimizing managerial and educational aspects of assessments.

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