

Development of Mathematics Question Banking System for Secondary School in Malaysia

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Abstract. A Mathematics Question Banking System (MQBS) is proposed and implemented at secondary school in Malaysia to allow teachers to collaboratively set, deposit and review online Mathematic exam questions. The psychometric properties of the Mathematics test question were first analysed using a Rasch Model Measurement computer program in order to ensure the best fitted items with appropriate level of difficulty before were included in the MQBS. Currently, 303 well-developed from various topics exam questions that fitted the Rasch measurement model were installed in the MQBS. Using the system, teachers can prepare valid and reliable exam papers according to the topics and difficulty levels in an easier, faster and more efficient manner. Besides, teachers can keep a collection of exam questions online with all the questions accessible by all other secondary school teachers in Malaysia. Since the MQBS is a web-based application, teachers can concurrently access it anytime and anywhere using an internet-enabled computer. The system supports Computerized Adaptive Testing where students can also use the system to take online examination and obtain their results immediately. Meanwhile, teachers could diagnose and monitor students' performance through their results generated by the system. Evaluation of the system was conducted at a secondary school in Malaysia and majority of the teachers who participated in the evaluation were satisfied with the MQBS and willing to adopt it at school.

Keywords: Question Banking System, Rasch Model Measurement, Computer Adaptive Testing.

1. Introduction

Preparing exam papers in secondary school is a tedious process which includes: (1) developing the exam questions, (2) digitizing it with text editor such as Microsoft Word, (3) piloting and reviewing the quality of psychometric properties of each question, and finally (4) printing out the exam paper. During the assembling process, teachers in privileges' school will use text books, sample questions booklet as well as commercial product such as IQ Gen [1] in setting the exam papers. Although IQ Gen could generates exam questions with different level of difficulties and categorize them according to topics, the questions provided might not be designed and calibrated in a conceptual order and grouped its level of difficulty. Ideally, exam questions should be calibrated using Rasch measurement in order to establish a valid and reliable test and investigate its' suitability for students [2] as well as for tracking and monitoring student learning performance. In addition, the implementation of new School-base Assessment initiatives require teachers to develop a high quality test paper. Thus, the use of off-the-shelves product might not be able to analyze the real performance of students. Conventionally, teachers would use resources provided by their school to set exam papers and seldom exposed to external resources available in other schools [3]. As most of the secondary schools in Malaysia do not have a proper system to keep the digitized exam papers, only teachers who set it, owned a copy. This resulted to new teacher who need to spend more time and effort in constructing exam papers due to the lack of references to the past years exam papers. Besides, comparing and sharing of notes and exam papers among schools could hardly be made. This could lead to a huge contrast of exam questions among schools in terms of quality and standard. Thus, there is a high probability that the exam papers are either too

easy or too difficult. If the questions are too difficult, weaker group of students would not be able to answer it. Eventually, it will make the student lost interest in their studies and felt depressed and embarrassed in some cases, students will consider themselves as “stupid” which ended up quitting schools [4]. Therefore, a web-enabled centralized Mathematics Question Banking System (MQBS) is proposed and implemented to help secondary school teachers by: (1) Reducing time spent on assembling of exam papers; (2) Collaborative authoring environment; (3) Auto generates calibrated exam questions that placed on a common and linear scale using a Rasch measurement model, which is greatly effective in item analysis and unidimensionality assessment [5]; and (4) Provide online examination to students. This paper is organized into five sections. The next section provides related works to the system. Section 3 describes the design and development of the MQBS and Section 4 discusses the evaluation result. The conclusion is given in Section 5.

2. Related Works

Question Bank or also known as Item Bank refers to a large collection of good test items with their quality analysed and acknowledged. Item bank assists users in the search and application of different testing procedures according to their needs as all the items are systematically organized throughout the processes. The well-tested items (exam questions) are being stored in a computer systematically so that it is accessible to students in order to evaluate their achievement or ability [5]. Each test item is statistically calibrated to be linked on the same interval level, scaled in an item bank by using item response theory (IRT) method such as Rasch model [2,6]. WINSTEPS, a calibration software coupled with development in computing power (Computerized Adaptive Testing - CAT) that supports numerous applications of the Rasch model, mainly in the areas of educational testing, attitude surveys, rating scale analysis etc., can be applied to Malaysian educational assessment [2,5,7]. Any new items meant to be inserted into the item bank for measuring the same trait could be validated and calibrated onto the existing scale of the bank. A Rasch item bank enables the testing programs to be constructed in a flexible and appropriate manner, as different groups of students can take different items which are suitable to each of them and the results can still be compared on a common, calculated linear scale as all the items are calibrated.

3. Design and Development of the MQBS

The MQBS is designed as web application to support three types of users namely Administrator, Teacher and Student. Each type of user has different privilege in using the system and is associated with different modules as shown in Fig. 1. Teacher would use the MQBS to upload exam questions into the temporary database system and create online Teacher Made Tests (TMT) for students. Subsequently, students can sit for the online TMT and get their results immediately upon completing the tests. The coding response (students’ answers) will be used by administrator to calibrate the exam questions set by teachers using WINSTEPS. Questions that bypass the validation process will then be stored in the actual MQBS’s database. The entire lifecycle of the exam questions in the MQBS is summarized in Fig. 2.

3.1. The Administrator Application

- Users Management Module: The system allows administrator to register accounts for users (teachers and students) through the user management module so that each of them can log into the system as different role. This is to prevent students to register themselves pretending to be “teacher” and gain access to the MQBS to obtain questions. Personal details such as name, address, email, contact number etc. will be keyed into the database during the registration process.

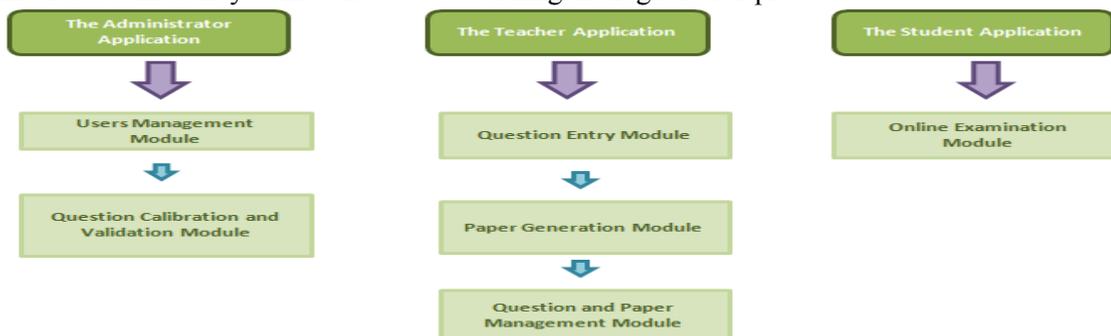


Fig. 1: Type of modules associated to different type of user in the MQBS.

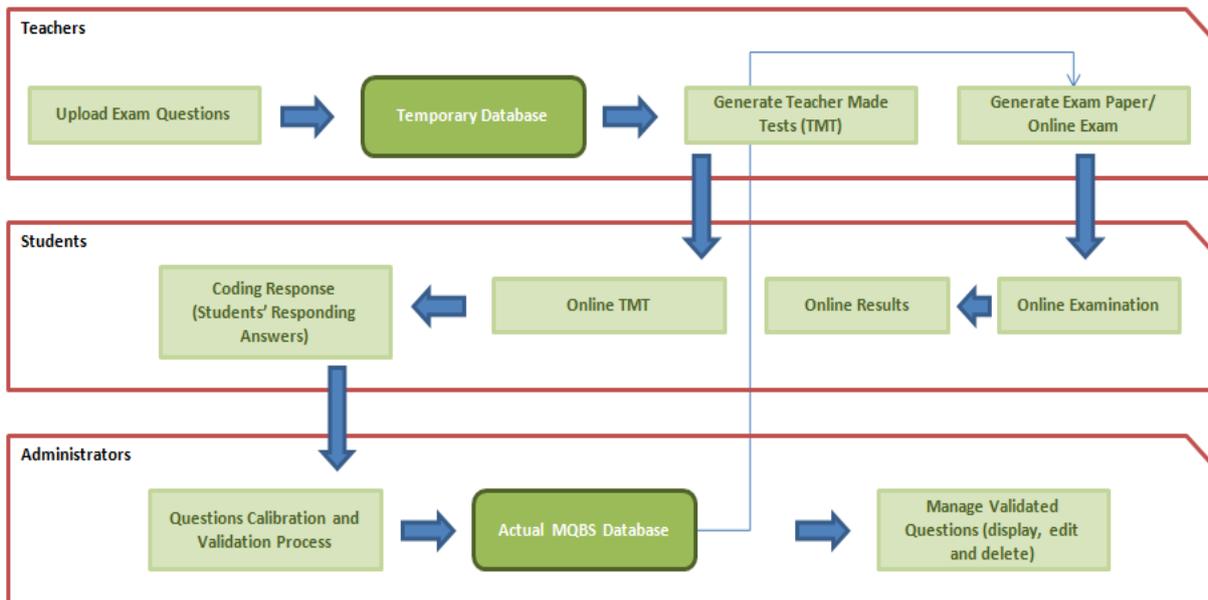


Fig. 2: Life cycle of the exam questions within the MQBS.

- Question Calibration and Validation Module: Administrator will use this module to validate questions uploaded by teachers through mathematical modelling software – WINSTEPS. Administrator will send the coding responses (answers provided by the students for each exam questions) to WINSTEPS in order to calibrate, analyze and check the validity of each exam question as shown in Fig.3a. Qualified exam questions will be uploaded to the actual database of the MQBS. The module also allows administrator to view the exam questions according to difficulty levels and topics, to edit the exam questions uploaded as well as deleting the exam questions as shown in Fig.3b.

3.2. The Teacher Application

- Question Entry Module: The module allows teachers from various schools to work together and contribute to the question bank anytime and anywhere. The contributed questions will be visible to all the teachers using the MQBS.
- Paper Generation Module: The module assists teacher in selecting questions from the MQBS or automatically generating exam papers based on the difficulty levels and topics in HTML, Microsoft Word or PDF format. Date and time to publish the exam paper can be set and available to the Student Application accordingly. Exam papers which exceed the set date and time will automatically be appeared as past year's papers in the Student Application.
- Question and Paper Management Module: This module enables teachers to edit, delete and achieve the questions or exam papers whenever necessary from the temporary database.

Students Response Coding

No.	Tutorials	Students ID	Question	Student's Answer	Correct Answer	Coding
1	Tutorial 1	students	1	A	A	1
2	Tutorial 1	students	2	D	B	0
3	Tutorial 1	students	3	A	D	0
4	Tutorial 1	students	4	D	D	1
5	Tutorial 1	students	5	B	B	1

[Save Table in Excel Format](#)

3a: Sample of the Students' Coding Response

Web-based Question Banking System

MQBS

Uploaded Questions

No.	Level	Topic	Questions	Answer/Update/Delete
1	Easy	1 Directed Numbers	$8A + 8B = 12C$	Edit Question Edit Figure
2	Easy	1 Directed Numbers	Which of the following has the largest value? Antara berikut yang manakah mempunyai nilai terbesar? A) $2 + 3 + 4$ B) $1 + 25 + 45$ C) $4 + 3 + 45$ D) $15 + 15 + 45$	Edit Question Edit Figure
3	Easy	1 Directed Numbers	Multiply 208 by the quotient of 240 and 15. Darabkan 208 dengan hasil bahagi 240 dan 15. A: 48 850 B: 48 800 C: 3 328 D: 142 800	Edit Question Edit Figure
4	Easy	1 Directed Numbers	Which of the following has the lowest value? Antara yang berikut yang manakah mempunyai nilai terendah? A) $150 + 40 = 3$ B) $150 + 4 = 2$	Edit Question Edit Figure

3b: Managing Questions through the MQBS

Fig. 3: User Interface for the Question Calibration and Validation Module.

3.3. The Student Application

Online Examination Module: Students would use the MQBS to take online examinations according to the date and time set by teachers as shown in Fig. 4. The countdown timer will appear in the Student Application to notify students about the amount of time left for the examination. A pop up reminder will appear if student submit their answer before finish answering some questions, to prevent unintended submission. The module is also responsible for marking the online examination automatically.

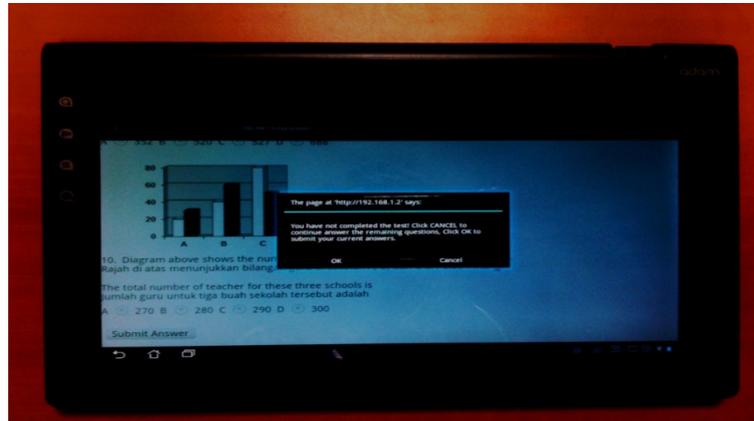
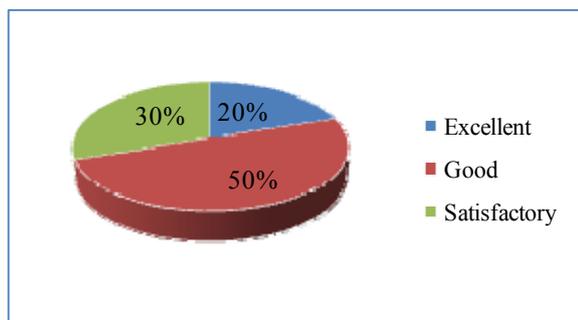


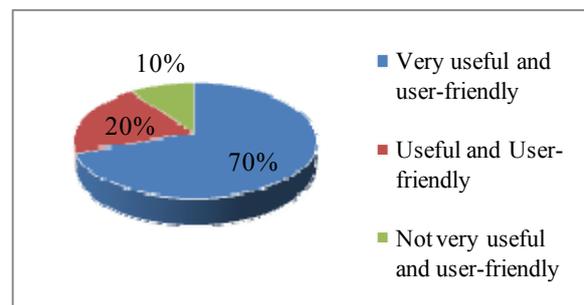
Fig. 4: Taking Online Examination through the MQBS on Android tablet

4. System Evaluation and Discussion

Ten teachers from the St. David High School, Malacca, Malaysia were randomly chosen to participate in the evaluation of the MQBS. Prior to the evaluation, the teachers were demonstrated on the usage of the system by the facilitator to make them familiarize with the MQBS. Hence forward, the teachers were required to discover the various features provided by the system for about twenty minutes. After which, a 5-point Likert-scale questionnaire are distributed to the teachers to get feedbacks on the usefulness of the system. User interface of the MQBS was mostly accepted by the teachers with half rated it as "Good" while 30% rated it as "Excellent" as illustrated in Fig. 5a. The concept of filling up web form in the authoring process is also well accepted by the teachers. The teachers were pleased with the MQBS, where all the examination questions can be shared among the schools in Malaysia. Majority of the teachers (90%) believe that the MQBS is useful and will be able to save their time and effort in preparing examination papers as well as in marking the answer sheets (refer to Fig. 5b). However, one participant commented that the system may not be very useful as teachers can easily obtain exam questions from various online web pages [8-11] or through commercial products. Although questions can be obtained via websites and proprietary products, the questions are usually not being validated by proper calibration processes. Whereas, questions stored inside the MQBS are validated with WINSTEPS, thus ensuring the quality of exam questions.



5a: Rating on the MQBS User Interface



5b: Rating on the Usefulness and Friendliness of the MQBS

Fig. 5: Evaluation result on the MQBS.

5. Conclusion and Future Work

The web-based Mathematic Question Banking System presented in this paper could potentially help teachers at secondary school through (1) resource sharing through online collaboration among teachers: (2) time and efforts saving in constructing and marking the exam papers: and (3) calibrated online examination. The trend of using question bank with CAT is likely to become popular in Asian countries because of the increasing use of computers and Rasch measurement modelling in education assessment and certification of student achievement. As the current system is only at the prototyping stage, a full scale evaluation of the MQBS in different schools for both teachers and students will be realized using various devices such as iPad or Android tablet in the near future.

6. Acknowledgement

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7. Reference

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