Designing an Adaptive Question Bank and Question Paper Generation Management System

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Abstract. This paper discusses design and implementation of automatic question paper generation and retrieval system for the engineering domain. The system uses C#.NET for user interface design. SQL server 2017 is used for database storage. Question paper generation is accomplished using SAP crystal report 2016. The system consists of four modules namely administrator and login module, question input module, question retrieval module, and evaluation module. The question paper is generated using a dynamic algorithm with minimal redundancy. Since the inputted question items are marked for their difficulty index, the question paper may be customized as per testing requirement, i.e., basic to advanced level of difficulty. Evaluation module generates password protected expert validated answer keys for the objective type of questions and answer cues for subjective type of questions. The system may duly cater to the need of instant generation of confidential different sets of question papers having same difficulty index for the purpose of competitive engineering examinations or tests.

Keywords: Assessment system, Automatic evaluation, Question bank, Course outcome.

1 Introduction

Tests and examinations are part of competence and performance evaluation of learners in both formal and informal institutional setups. They are used to determine an individual's potential, suitability, and also as means to assess learning outcome. While the Universities' paper setting guidelines usually takes only format of question paper into account; quality of the question paper is rarely focused upon due to time and human constraints. It is rather challenging for the teachers to cover all the aspects of the course objective and avoid duplication of questions [1]. While there is yet a general consensus about the essential role and intervention of a human-teacher in the teaching-learning process, revolution in the technology has made it possible for computers to assess and evaluate the learners' performance in many areas of studies. With Universities and other educational institutions expanding their reach to students globally and largely through online and distance mode courses, there has emerged a parallel requirement for their objective, automated, fast and secure assessment process absent of much human effort and monetary burden.

A few efforts have been made for development of questioning and evaluation systems. Products like "WebAssign" [2,3] and "WebCT" [2,4] provide immediate feedback on every attempted question. Physics Homework System (The Andes Physics Tutor) is also an example of similar work. These question items either strictly follow categories as given in Blooms Taxonomy [5,6] or as these category may deem fit into in a particular area of subject into account. MILES contains a vast database of question items for Hindi, Tamil, Kannada, Telugu, and Urdu languages for assessing language proficiency among second language learners of these languages [7]. A paper generation systems using J2EE tools based on B/S architecture is proposed by Cen et al. [8].Summary Street, a computerized tutor based on Latent Semantic Analysis (LSA), provides support to students on content writing, summarizing, etc.; it also provides continuous feedback to students [9]. Some systems focus more on assessing performance rather than providing a mechanism for automation [10]. Research indicates that students using this technology may score significantly higher. LSA based system, APEX, assesses the writing skills [11]. There are some other question paper generators based on RDBMS or linear searching method and therefore question selected from database are often inefficient unless all of these questions are marked for their difficulty index and duly validated by experts.

Further, in this paper, the overall architecture of our system giving detailed working of its four modules namely Administrator Verification and Login Module, Question Input Module, Question Retrieval Module, and Evaluation module have been discussed. Also, advantages and future prospects have been explained from the perspective of users and implementation.

2 System Architecture

The system being discussed here broadly has four modules, namely: Administrator and Login Module, Question Input Module, Question Retrieval Module and Evaluation Module.

2.1 Administrator Verification and Login Module

This module primarily verifies the authenticity of the username/password of the item writer, data inputter (question inputter), and question retriever. Every item writer is assigned with a unique ID denoted as iw_id in the database. Academic and professional credentials of the item writers such as name, qualification, areas of expertise, designation, professional affiliation, and contact details are also stored as metadata in the database for the purpose of further verification and cross reference in the future. The details of the question inputters are also stored.

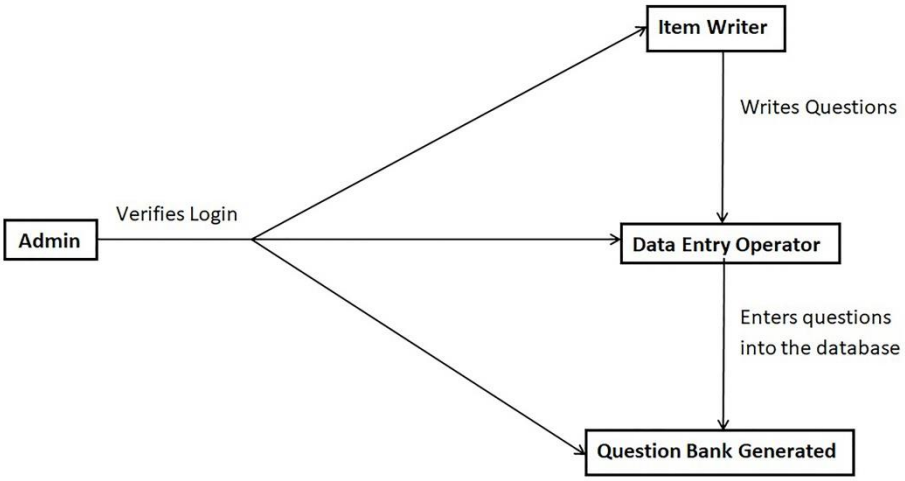

Fig. 1. Administrator verification flowchart

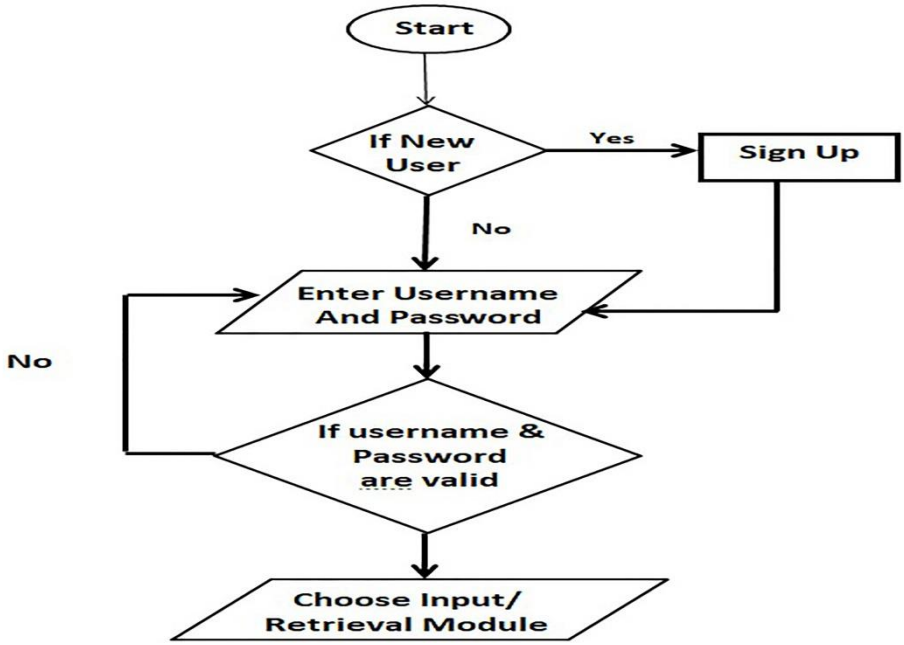

Fig. 2. User login flowchart

The system provides access to three different users viz. an administrator, a question inputter and a question retriever. Item writers provide the questions to be stored in the database to the question inputters who in turn feed them into the database. As evident from Fig. 1 and Fig. 2, unique IDs are created and assigned to both for item writers and/or question inputters through a sign up process. Created IDs are verified and approved by the administrator on account of their professional credentials. After the approval of IDs, question retriever and/or question inputter can log into the system. Question inputters have access to the question input module, whereas the question retrievers have access only to the question retrieval module. Unlike question inputters and question retrievers, the administrator has access to both the question input and question retrieval modules. Pattern matching and OTP based authentication are used for the purpose of secure accesses.

2.2 Question Input Module

This Module is the part of the system where questions are inserted into the database by the question inputters. Question items are prepared by established professionals and academicians in their respective areas. Item writers type the questions on a MS Word doc (user-friendly) format; whereas question inputters have to feed the question items into database through a uniquely designed application form. It classifies subjects/areas/content based on the seven parameters which need to be considered

before entering question items into the database. These parameters are such as Instruction to the examinee, *Question/Item Stem (with answer key/cue), Scoring Procedure, Course Outcome, Item Type/Format used and Difficulty Level.* These parameters indirectly relate to six cognitive levels as given in Bloom's taxonomy namely *Recall, Understand, Apply, Analyze, Evaluate and Create* [5]. Each subject is assigned with a unique identifier to make the identification easier. These identifiers help generation and retrieval process easier. Also, question count may be done from time to time to see the number of items under a specific subject/topic. Therefore, in case, a piece of information changes with time under a particular subject/topic, new question items may be added, deleted or modified to keep the question bank most suited for contemporary needs.

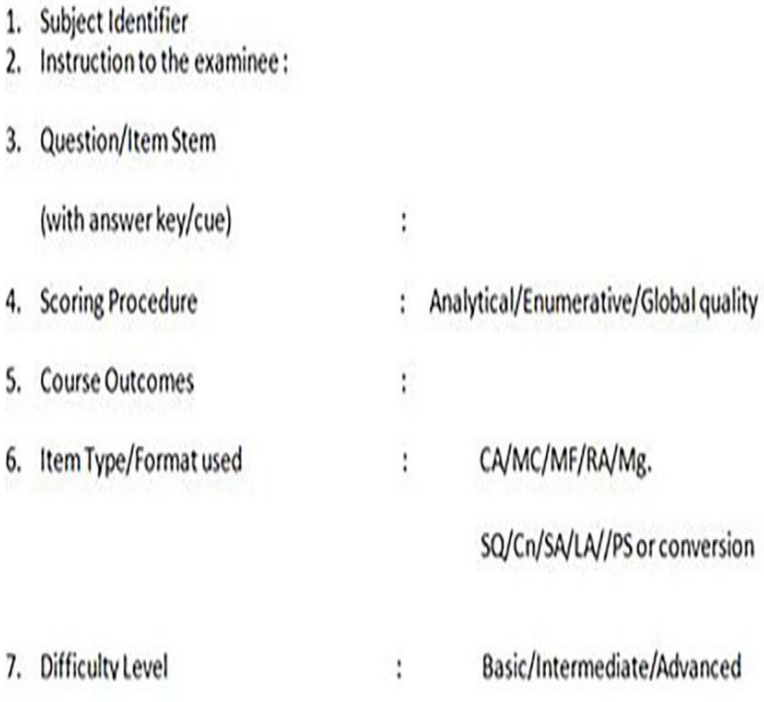

Fig. 3. Question item format

Fig. 3 represents a MS word template/doc format of the question input format presented to the item writers. The parameter 1 indicates identifier (a specific numerical code) assigned to a particular subject/area. Question item writers usually write the name of the subject/topic under which a given question item falls within. These identifier codes are assigned by the data inputter from Subject Identifier Tree Diagram (SITD). In cases, when one question may fall within more than one subject scopes, subject identifier is assigned to the most suited category after due validation from the experts other than the item writers. The parameter 2 provides space for the specific instructions which are to be conveyed to the examinee before attempting the question. The parameter 3 is Question Item Stem (QIS) in which actual question item is written with its respective the answer key/Cue. Question Items and Key/Cue are fed into separate columns in database through question Input form (QIF) a by data inputter.

The parameter 4 provides the question inputter with an option to specify the scoring procedure as it is defined by the item writer. In principle, there are three types of scoring procedures – Analytical, Enumerative, and Global Quality. But presently most of the questions inputted in this system follow analytical procedure for the purpose of scoring. The parameter 5 measures the course outcome. The course outcome is nothing but the main objective behind a asking a particular question. In this system, course outcome is defined to be of three types – Analytical, Understanding and Educational, following Bloom's taxonomy [5]. The parameter 6 is item type, i.e. objective or subjective type, and also format used for the particular inputted question. In objective category, there are five types of questions- constant alternative, multiple choice, multiple facet, rearrangement, and matching, while subjective type of question are of five types namely - simple question, completion, short answer, long answer, problem solving & transformation. The parameter 7 measures the difficulty of a given question item. This system makes use of three levels of difficulty namely Basic (low, 0), Intermediate (medium, 1) and Advanced (high, 2) for the purpose of understanding. However, there is a scope of further refinement of difficulty layers making it more suited for the different levels of education such as Primary, Secondary, Higher Secondary, Graduate and Post Graduate.

2.3 Question Retrieval Module

This module takes in different inputs for generating the question paper. This system generates the question paper with the help of pre-request form. In the pre-request form, the requester has to fill the details of total marks, question type, branch, semester, subject/topics, difficulty, etc. These questions may further be divided into further sections or subsections as per the requester's need in line with the parameters given in Fig. 3 and as discussed in section 2.2. Since the inputted question items are marked for each parameter, a question paper may be generated to cater to different types and levels of testing requirements.

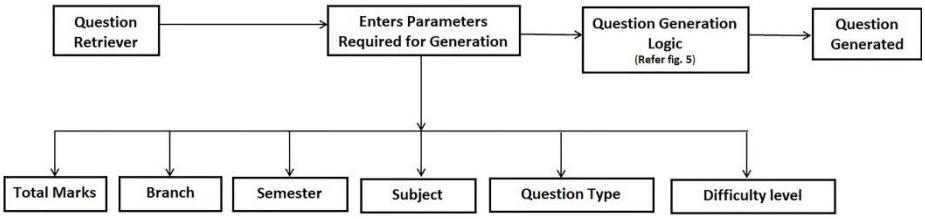

Fig. 4. Question retrieval diagram

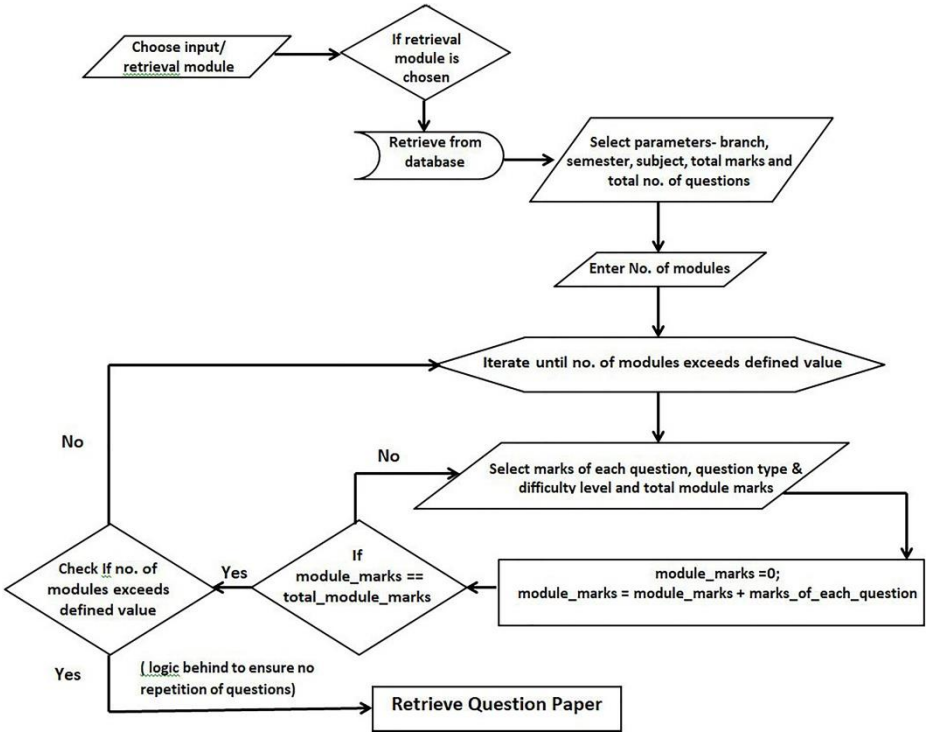

Fig. 5. Question retrieval flowchart

Fig. 4 shows the diagram of the Retrieval Module, while Fig. 5 shows the functional flowchart of the module. Based on the requester's requirement (given in request form), the retriever selects the various parameters given in Fig 3, and manually entered them into question retrieval window. Probability of redundant retrieval of question items is very low**.** To achieve normalization, separate tables have been made to store the details of individual subjects & branches with corresponding unique identifiers. Similarly, question/answer stems and answer cues consistent with certain predefined parameters are stored in separate tables. Built-in SQL server and ASP.NET functions checksum and random, respectively, are used for the purpose of

retrieval. The ID associated with each question is passed as a parameter to these functions which help retrieve a new question. All parameters are independent of one another, i.e., selection of a parameter does not affect or limit the scope of another parameter by any manner.

2.4 Evaluation Module

This module helps paper evaluators to make the process of paper evaluation easier and faster. As mentioned in the design of the input module, answer keys for the objective type of question items and answer cues for the subjective type of question items are also fed into the database along with their respective question stem. While answer keys are fixed to the objective type of question items, there can be various ways to provide an answer to a subjective type of question item. Therefore, the answer cues are written in such a way that it provides an analytical breakdown of the whole answer with marks assigned to each part of the answer. This breakdown of answers serves as a standard for paper evaluators to provide marks without any discrepancy. The answer cues provided in the evaluation module are consistent with the course outcomes of the course whose question paper is being generated. Automated evaluation is achieved using stored answer keys using simple conditional constructs. Manual evaluation of the subjective type of question items is done following stored answer cues. Since subjective question items do not have fixed answering patterns, answer cues with their analytical breakdown are fed into the system for system to recognize specific patterns in writing content. We can come to the conclusion that the evaluation module removes the prospect of bias in paper evaluation to a major extent.

3 Implementation of the System

For designing the graphical user interface (GUI), C#.NET is used. First screen comes with the options of Administrator, Item Writer, or Inputter login. Based on the type of login, second screen auto appears. For example, an item writer gets a screen as given in Fig. 3 (a MS Word template), however, for data inputter, following screen appears for entering the question items based on the seven parameters.

Once one question item is properly inputted and saved, the new question item may be selected from the item writer question format. For storing the question bank SQL 2017 server is used, and SAP crystal report 2016 is used for generation of the question paper. The administrator has a privilege login and therefore s/he can generate the question paper and respective answer key/cues as requested by the requester.

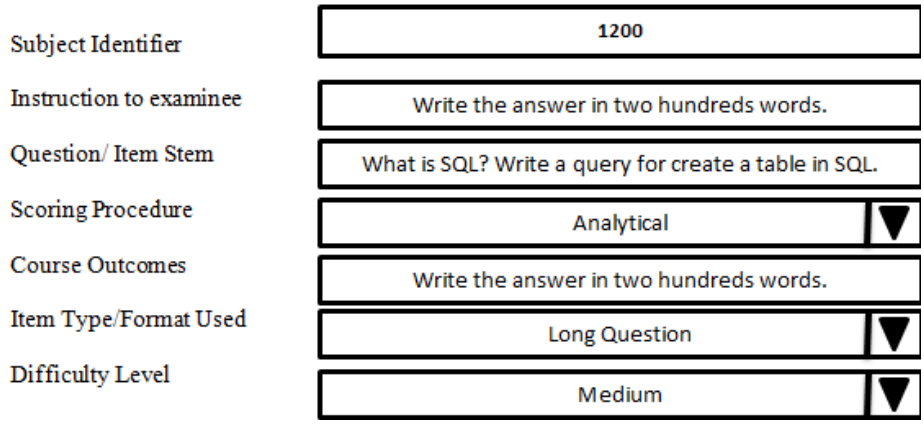

Fig. 6. Question input window

4 Advantages of The System

The main advantage of this system is that it reduces human effort as well as needs of different resources that are used to generate a question paper. The proposed system greatly reduces the possibility of postponement or cancellation of examination in case a question paper gets leaked or is tampered with by someone. Since, generated question paper has minimal redundancy, different sets of questions paper for same subject, same difficulty index, same format, etc. may be prepared simultaneously, and therefore making it an ideal system for any competitive or entrance examination. The system is dynamic in nature, i.e., new question items can be added or modified depending on the requirements, and therefore as the passage of time, systems have the capability to become more robust. Overall, the system may duly cater to the need of instant generation of confidential different sets of questions.

5 Future Enhancements

Apart from fulfilling our basic objectives, this system may be improved in terms of the reachability and efficiency. For example, it may be enhanced to become a web application as opposed to desktop application. The system may be customized to work in any area of engineering, science, humanities, etc.

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