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Research Paper

BLOOM'S TAXONOMY-BASED EXAMINATION QUESTION PAPER GENERATION SYSTEM

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Abstract

Assessment process is an essential activity in educational institutions to test performance of the learners. The essence of examination papers is directly linked to evaluation of quality of the graduates. Nevertheless, designing question papers is laborious task for the academics. This paper is aimed to research and analyze current assessment process and build automated examination question paper generation system (AQPGS) to replace manual method practiced by academics. AQPGS prototype is intended to enable academics to produce quality examination papers on the click, that are unbiased and aligned with learning outcomes, while saving the time and resources in the assessment process. System prototype was developed in Visual Basic language and connects to MS Access database. It includes MCQ, True/False and open-ended questions. Mapping algorithm is integrated for automated categorization of open-ended questions according to Bloom's Taxonomy hierarchy, using keywords query and random selection of questions. Generated paper can be saved into text document and edited.

Key Terms: *Assessment System, Automation, Question Paper Generator, Bloom's Taxonomy System , Mapping Algorithm.*

1. Introduction

As an education is a key to success, the examination process is a critical activity for educational institutions to evaluate performance of learners. Content of the exam papers is the main criteria to ensure the education quality level of the students brought out by the institutions. Examination as well serves as a guide to students in their gradual journey to knowledge. That is why proper examination paper compilation procedure is essential.

However, manual preparation of the examination papers may be very tedious, time-consuming and challenging routine for academic staff if the institution does not practice computerized method of compiling the materials. Therefore, the subject of this research is examination process at FTMS College, aimed to evaluate the drawbacks of current manual method and analyze assessment process in terms of discrepancy and resources use. The outcome of this study shall be development of more efficient solution to enhance examination paper preparation procedure and a recommendation on how to further improve assessment process.

This paper shall include the outline of the information gathered from the publications relating to the area of research and interpretation of those facts into current study, analysis of data

collected from users and the findings, system structure design and development of a prototype of automatic question paper generation system based on Bloom's Taxonomy. The proposed system aims to provide an efficient alternative towards overcoming the issues associated with manual process of assessment preparation.

2.   Literature Review

2.1 Importance of quality assessment in education.

In the context of education, definition of assessment includes a number of procedures and methods that instructors apply to measure, evaluate and record the academic preparedness, learning progression, skill attainment, and academic needs of students. Thus instructors can provide customized instructional guidance, lesson planning, or social services (The Glossary of Education Reform, 2015).

According to Ewell (2008), since the past decade global tendency in higher education has drifted away from the conventional teacher-centered approach which focused on the instructor's input and assessment in terms of how well the students absorb the materials. Such assessment method was considered too limited in evaluating learning, neglecting the nature of coherent ability that is meant to integrate various individual skills into overall practice. Hence the education trend has shifted towards student-centered perspective concentrating on the learning outcomes, or what the learners are expected to be able to do at the end of the studying experience. Furthermore, employers and educational strategists will be better be aware of the graduates' capabilities for employment and liability purposes (Ewell, 2008).

Learning outcomes denote the students' accomplishments as an outcome from involvement in a certain set of teaching and learning activities. The three classifications of learning outcomes of students are: cognitive, affective and psychomotor (Bloom et al., 1956).

It is essential that teaching and learning experiences, learning outcomes and the assessment are developed to comply with the three affiliated components (Biggs, 1996; Biggs, 1999; Biggs and Tang, 2011). Combination of these elements will determine conformity and uniformity within the syllabus where the expected learning outcomes align with the teaching, learning and assessment processes in a logical and consistent way.

It is deduced that student-centered approach to the organization of educational processes provides for better learning and more genuine student assessment. It has been also determined that such method is particularly essential for education of Information Systems students (Landry et al., 2008).

Indeed, constructing a broad and methodical assessment system is a tough task. Luckily there are mechanisms and approaches specifically aimed to ease this work. However those procedures cannot substitute expert judgment but to complement it. Generating a balanced comprehensive assessment system requires right perception, supervision, cooperation, communication and acceptance of change (Oliver, 2015).

2.2 Bloom's Taxonomy in Assessment.

As pointed out by Veilleux (1999), academics often concentrate on material coverage and consider an assessment complete if all main course topics are included in the exam. Coverage of material only concerns the breadth of students' knowledge, however of late an alternative method is preferable to assess its depth. Assessment of knowledge depth can be organized in accordance with Bloom's taxonomy. Taxonomy-based exams measure the level of learners' comprehension by including an organized set of questions, varying from easily resolved by a learner who grasped basic material, to cases which require creative approach in applying various techniques. Based on the difficulty level of the questions given, students' papers are marked according to fixed criteria, and not based on grade averages.

One of the most problematic tasks of question paper planning is achieving a balance in multiple question types which call for different levels of comprehension. Alternatively teachers can compile diverse examinations involving questions with graded difficulty. If a teacher specifically creates various understanding questions (short questions with a 40% grade allocation), application questions (less straightforward questions with 40- 50% of grading scheme) and a few analytical open-ended questions (another 10- 20% of marks) to make sure that students who have acquired each level, can show their performance - then marking gets less complicated and less disputable.

Veilleux (1999), further defined how academics benefit from applying Bloom's Taxonomy to ensure they are not missing out essential items out when compiling assessment and are as follows:

(1) Frequently instructors find themselves perplexed by multiple standards and syllabus requirements. While Bloom's taxonomy provides a guiding model for subdividing those norms into approachable blocks that can be applied in making routine class plans and also can be aligned with instructor's own class objectives. Same as certain levels require certain comprehensive delivery approaches, they also require specific assessment techniques.

(2) Taxonomy can be utilized as an index to verify that all levels of domain are being assessed and correspond the assessment tools with the relevant lessons and techniques. Thereby, Bloom's Taxonomy also helps educators to retain uniformity in assessment practices, educational materials and reveal weak spots.

(3) Reference to the elements of taxonomy is a supportive tool for defining objectives and monitoring how well the students understand material. Besides defining the objectives, application of Bloom's taxonomy is also extremely useful in assessing students' comprehension of concepts. Referring to taxonomy levels and reviewing where the students stand among those, allow instructor to move forward from elementary to more sophisticated level of comprehension.

(4) A conclusive substantial benefit from assessment based on objectives is essentially meaningful marks allocation, thus less disputable grading criteria – which eliminates doubt among students regarding the grades given and there is no need for marking adjustments from the educator's side. It is an indicator of justified assessment mechanism that can also be used to guide educators in adapting the level of directives for new modules (Veilleux, 1999).

Vidakovic et al. (2004) opined that Bloom's taxonomy has been proven to be a helpful guideline structure for generating short answer, multiple choice, matching and essay questions which test students' knowledge in various cognitive exercises. The emphasis lies in classification of the test item in a specific level of Bloom's taxonomy depending on the highest level of cognitive problem presented to the student.

2.3 Advantages of Using Information Systems in Assessment.

According to Sofield (2000), many developing countries have not fully utilized information technology as a way of socioeconomic development. Although educational institutions are progressively acknowledging significance of technology in education and examination practices, in most of the institutions examination process is still handled manually. Manual procedure has many drawbacks such as time consumption and resources wastage to purchase and store paper records; it may cause errors, data redundancy and duplication of work if the same data could be recorded by different examination board members; not communicating examination results instantly and precisely etc. Workload complexity increases, multiplied by number of subjects each instructor has to assess during academic session. By automating the assessment system institutions can reduce human involvement by acquiring the technology since it promises

concise storage, rapid data retrieval, tireless rigorous work of processing the information, instant communication of information to users. The recent cases of rail transport computerization and online banking are the prospect examples demonstrating the advantages of using information technology. Thereby learning management systems as well can be efficiently utilized for assessment purposes in higher education (Sofield, 2000).

Automated assessment management system dramatically decreases the amount of work and time instructors spend on manual tasks. Using AMS teachers can generate question banks for multiple subjects and upload supporting files and media in different formats. Among other advantages of incorporating AMS in an institution is fulfilling requirement of employers and certification agencies by generating digital evidence which they use to evaluate students' performance.

Another benefit is quick turnaround of examination results, thus feedback for enhancement can be executed instantly. AMS suggested for college use, provides structure for assessment data generation and management, allows the institution to determine and align learning outcomes of students, generate syllabus and assessment plans, record results, outline and track improvement plans according to findings (Plantefaber and Wentland, 2015).

2.4 Systems comparison

2.4.1 Manual vs automated

Table 2.1. Manual vs. Automated Question Paper Generation System

Manual	Automated
Prone to repetitions / duplications	Random and unbiased generation
Slow due to human labor	Speedy due to automation
Requires resources	Requires only PC connectivity
Many steps in sorting questions based on difficulty	Automated questions sorting based on difficulty
Questions used are not stored in one place	All questions are stored in database

Automated system will significantly lessen the efforts of an instructor, which allows generating a question paper in a few clicks based on the requirements, such as marks and difficulty level of questions. Shuffling algorithm ensures randomization in process of selecting questions from the database hence preventing duplication of the questions.

2.4.2 Similar Systems' Comparisons

Table 2.2. Comparison of proposed system with similar software

Features	FreshLogics Paper Builder	Quick Quest	School Scholar	Add men	Proposed system
Integration of Bloom's Taxonomy to determine question difficulty	No	No	No	No	Yes
Question bank database to store unlimited number of questions	Yes	Yes	Yes	Yes	Yes
Randomization of questions to eliminate repetitions	Yes	Yes	Yes	Yes	Yes
Print answer key	Yes	No	Yes	Yes	No
User-defined access	Yes	Yes	Yes	Yes	Yes
Scan input into text	No	Yes	No	Yes	No
Save questions with images and equations	Yes	Yes	Yes	Yes	No
LAN support	Yes	Yes	No	No	No
Spell-check	No	Yes	No	No	No
Automatic updates	No	Yes	No	No	No
Multiple languages	No	No	Yes	Yes	No

	No	No	Yes	Yes	No
Ability to generate any type of questions (MCQ, fill in blanks, short / long answer etc.)	No	No	Yes	Yes	No
Questions grading (by marks / difficulty / importance)	No	No	Yes	Yes	Yes
Multiple output format for generated paper	No	No	Yes	No	No

Even though proposed system lacks some useful functions compared to other software, it has one unique and essential feature for question paper generation - which is Bloom's Taxonomy integration for addressing questions' difficulty level. This particular function is crucial for the academics to build their question papers based on the taxonomy hierarchy.

3. Research Design and Methodology

For purpose of this research, quantitative method of data collection in a form of survey or questionnaire was selected due to being time-efficient while allowing to gather data from larger number of respondents from selected segment.

The objectives of this survey are to reveal the issues with current manual method of designing question papers, identify needs and requirements of users and conduct further analysis of collected data.

3.1 Questionnaire design

Questionnaire was constructed using MCQ to establish particular facts; as well as questions based on Likert scale system, where answer's likelihood ranges from least to most. Analysis of such answers would indicate number of users who agreed or disagreed upon statements in question.

Questionnaire consisted of four sections:
-Section 1: greeting respondents and introducing purpose of study;
-Section 2: demographic profile;
-Section 3: questions concerning current system;
-Section 4: questions concerning proposed system.

3.2 Survey administration

Google Forms was used as the questionnaire design tool, which built-in instruments allow for easy distribution, interpretation and analysis.

Intended audience for gathering data were the FTMS academics as primary users of the system. Questionnaire was distributed to twenty five staff including lecturers and Heads of Schools via e-mail and total of twelve responses were collected. Majority of 75% respondents were male and 25% - female. Such ratio is not intentional to target male category, as the survey is taken at random and the feedback was received only from three females of all questionnaire recipients.

4. Results and Discussion

4.1 Results analysis.

Analysis of selected questions is presented below. The questions selection is based on degree of relevance of the answers to the main problem.

Q1.

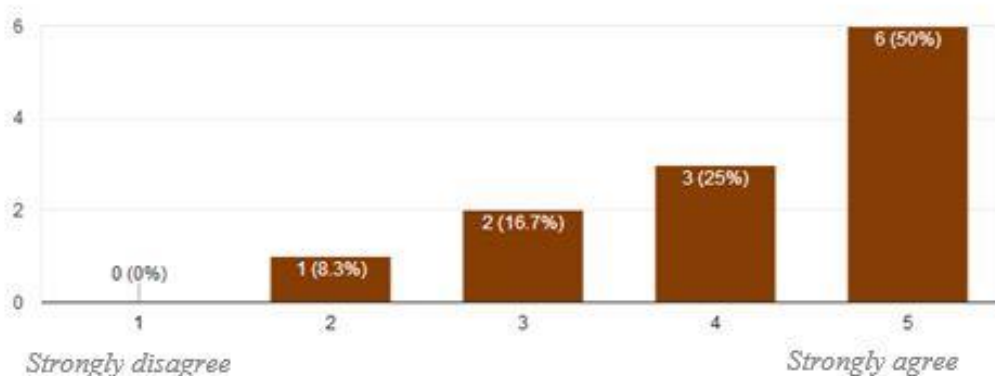## I usually have massive work load

12 responses

Figure 1. Level of busyness of the users.

Assumingly due to wide range of responsibilities, more than 90% of respondents agreed that they have massive work load. This illustration means that the lecturers, who answered the survey, are responsible for tasks such as preparing course materials, lecturing for 15 hours/ week, counselling, manually creating assessment questions, invigilating and supervising students. The result above means that the staffs are usually much occupied and automation of some of their tasks would greatly assist them in carrying out their duties efficiently.

Q2.

I am satisfied with current manual method of creating question papers:

12 responses
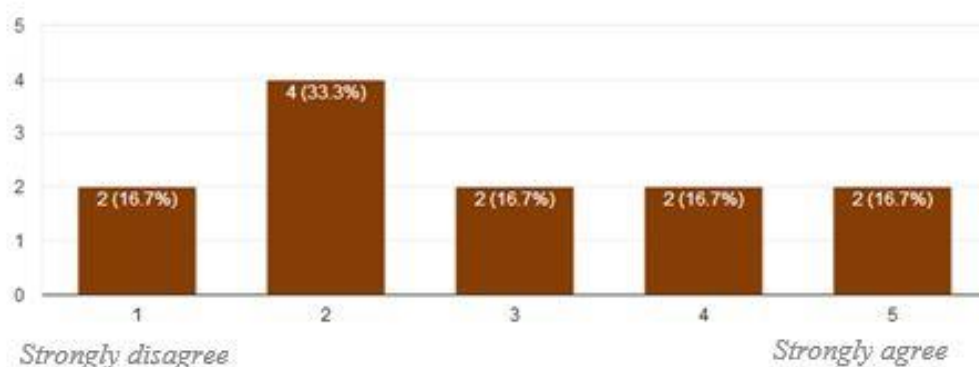
Figure 2. Level of satisfaction of the users with current method.

About 60% of lecturers are not satisfied with the manual method of designing examination assessment questions. As could be seen from the figure 2, more than half of the respondents are found to be discontented with the manual method of question paper generation as that method is time consuming and affects their ability to do other tasks, considering their work load. This also indicates the need for alternative ways to create the questions.

Q3.

Issues I find with using manual method of generating examination materials

0 / 12 correct responses
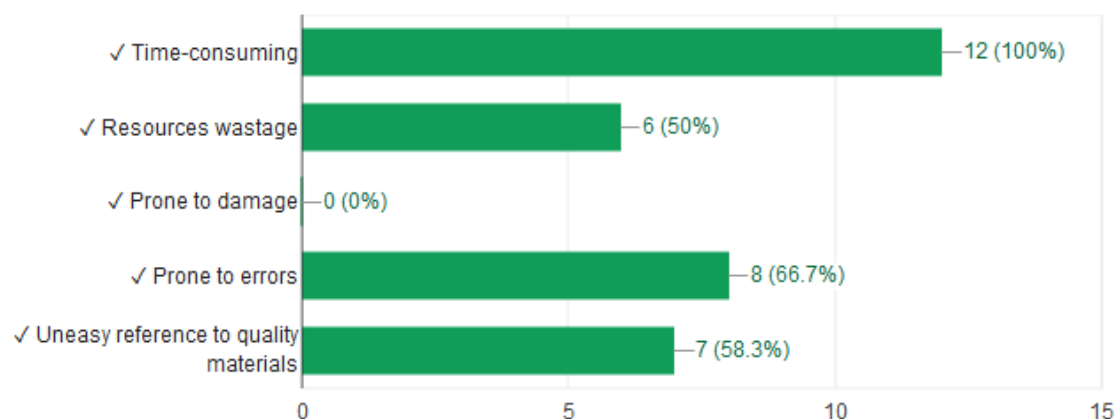
Figure 3. Issues with current method.

When asked to rate the major issues the respondents have concerning the current manual method of examination assessment, 100% of the respondents rated 'time-consuming' as the major issue that they experience, followed by the probability of making a mistake ('prone to error') which stands at 66.7%. The third issue rated by the respondent is the uneasiness of accessing good resources which stands at 58.3% and last but not the least, wastage of resources was rated fourth by 50% of respondents among the major issues the lecturers have with manual method of question paper creation.

Q4.

Provide time estimate to generate one question paper

12 responses

- 1-5 hours
- 6-9 hours
- 10-15 hours
- 16 hours and above
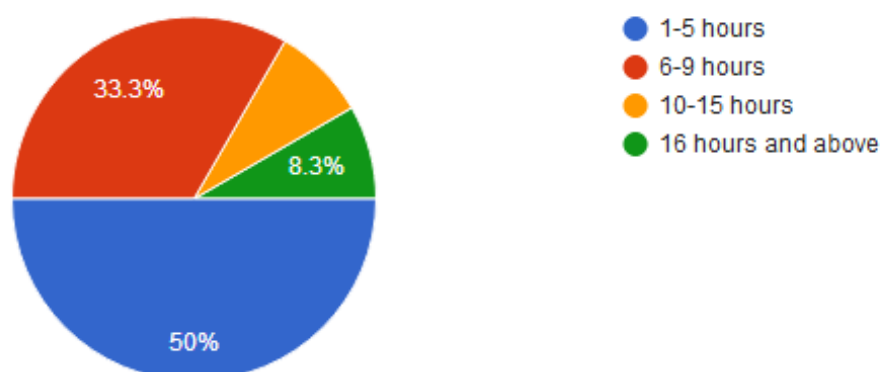
Figure 4. Time it takes users to generate one question paper.

Average time to design question paper for one subject takes up to five hours. Bearing in mind that each lecturer has to teach between 4 to 6 subjects. Hence, developing examination papers for each subjects is time consuming.

Q5.

Current guide used to set up questions up to the quality standards

12 responses

- Bloom's Taxonomy
- SOLO Taxonomy
- Marzano & Kendall
- Taxonomy of Significant Learning
- TeachThoughtSimple Taxonomy
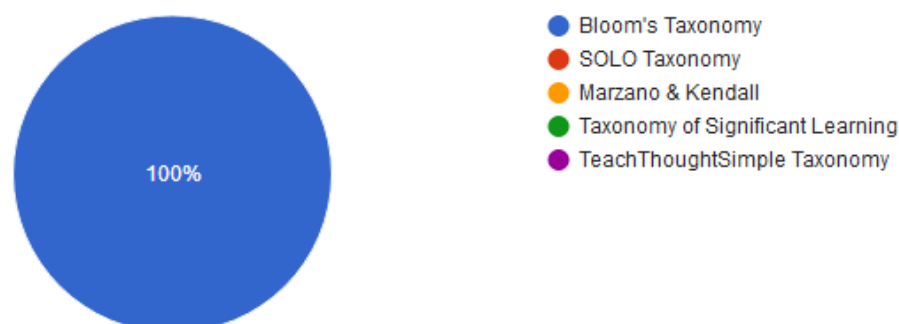
Figure 5. Guide used for questions set-up.

100% of the lecturers are referring to Bloom's Taxonomy as a guide for setting up examination questions.

Q6.

Sometimes even after collaborative review, errors are still found in papers during examination

12 responses
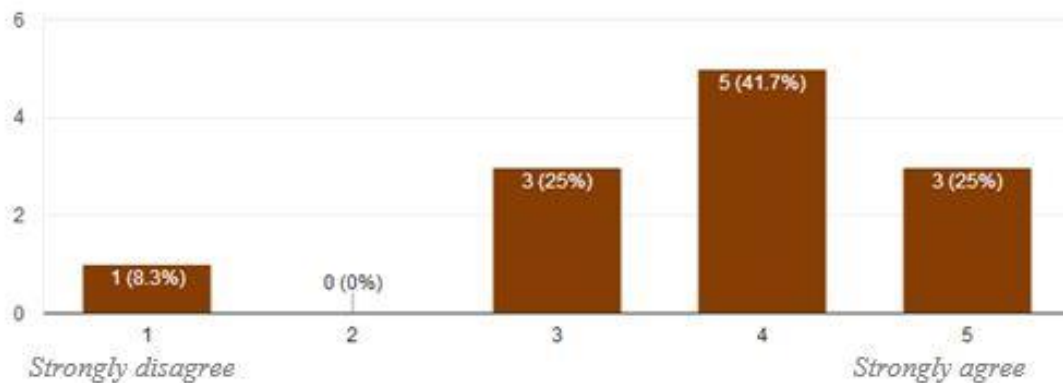
Figure 6. Proneness to errors

More than 90% of respondents agree that even after review and approval of question papers, there are still errors usually found with the final draft. These errors could be caused by exhaustion on the part of the setters using manual method.

Q7.

If automated system is developed, I would use it

12 responses
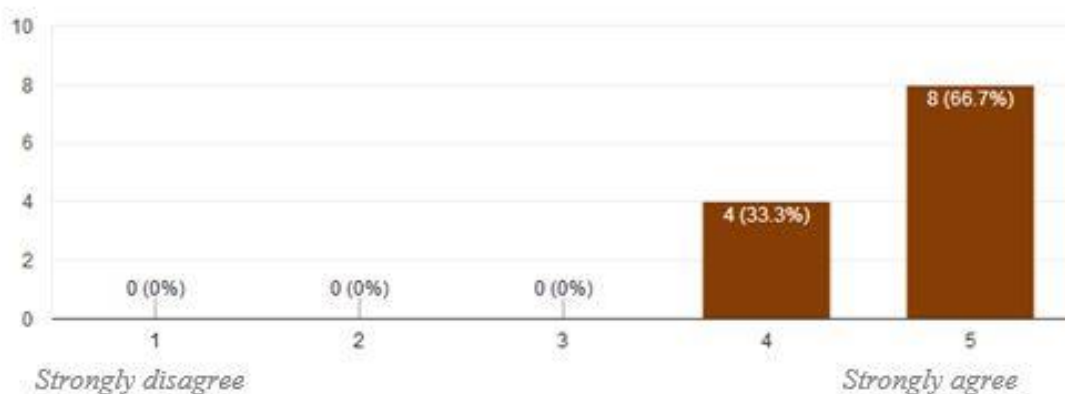
Figure 7. Likelihood of users using the proposed system

100% of respondents indicated their willingness to use automated system, there is no single negative answer to that. As they perceive the proposed system to be beneficial and could facilitate their ability to create the papers speedier.

Q8.

I believe automated system would perceive usefulness and be more efficient compared to manual method

12 responses
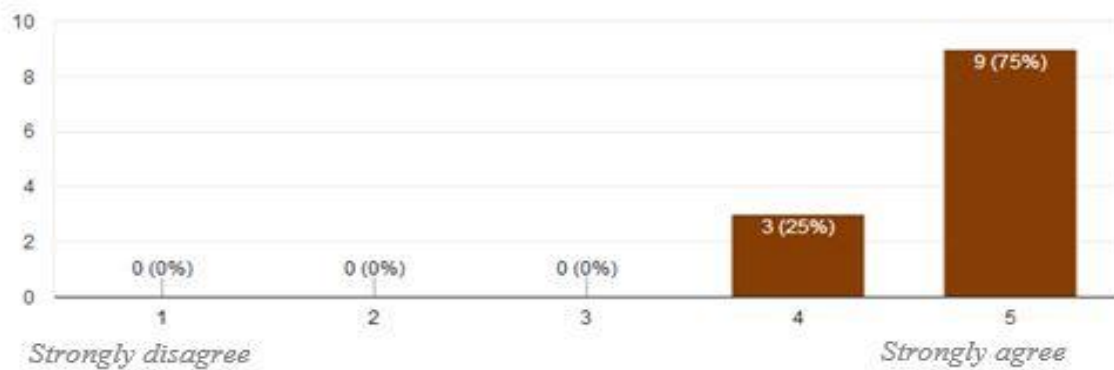
Figure 8. Usefulness of proposed system

100% of respondents find automated system more efficient and productive compared to manual.

4.2 Discussion of Findings.

From the questionnaire data analysis the following findings were identified: (1) majority of respondents are lecturers of SOECS with five to nine years of working experience, having four to seven subjects under their responsibility and are advanced computer users; (2) majority of respondents admitted having a massive work load due to wide scope of responsibilities besides lecturing and preparing materials, such as invigilation, MQA documentation, project supervision, managerial or marketing activities etc.; (3) majority of respondents are not satisfied with current manual method due to it being slow and time-consuming, prone to human errors even after exam board review, leads to wastage of resources and not being environment-friendly; (4) more than half of the respondents admitted that sometimes they fail to meet the submission deadline of the question papers, as it takes up to five hours to design question paper for one subject using lecture slides, books, online sources and categorizing questions according to Bloom's Taxonomy; (5) majority of respondents indicated that they would highly likely use automated system, as they find it more efficient and useful due to processes automation and added features such as user security via login authentication, ability to save questions in database and save generated papers as soft copy.

4.3 Proposed System Design.

Data flow diagram is used to depict flow of data inputs and outputs in the AQPGS through its processes and where the data is stored. Symbols used are according to Gane and Sarson notation.
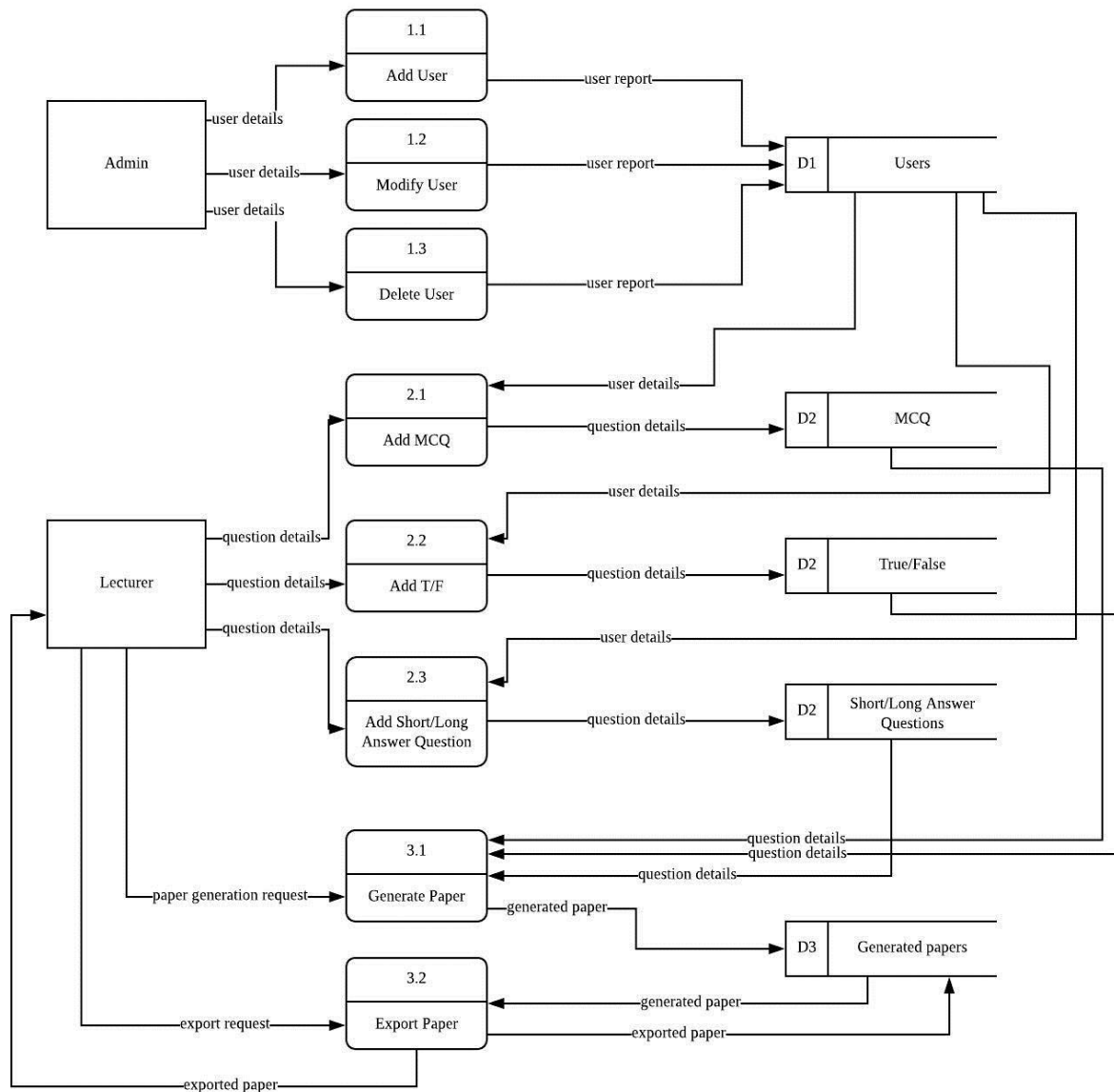
Figure 9. AQPGS DFD Level 1

From this graphical representation we can see the functions AQPGS prototype supports. For Admin: to Add, Modify, Delete users and store their information in database; for Lecturer: to Add three types of Questions and save them in Question bank database; Generate question paper and Export the result. System returns generated paper and exports it into user's computer.

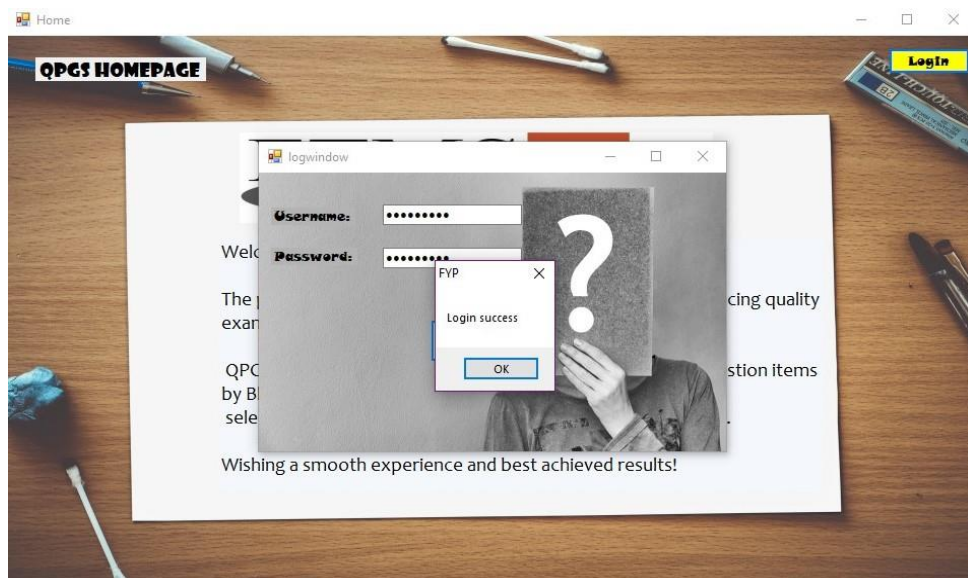## 5.   Proposed system implementation

5.1 Interface designs and main functions.

Figure 10. Homepage interface and Login window.

Before user is able to access system, it is necessary to pass the authentication step through login form where user must enter the correct username and password given by system administrator. If user has administrator role, login form will redirect to Admin Portal. If login details match a lecturer role, user will be redirected to Lecturer Portal.

Figure 11. Admin Portal interface.

Once user entered username and password which belong to admin role, Admin Portal form is shown, from which Admin can: add new users, modify user information and delete users.

Figure 12. Admin Portal: Add/Modify/Delete User form.

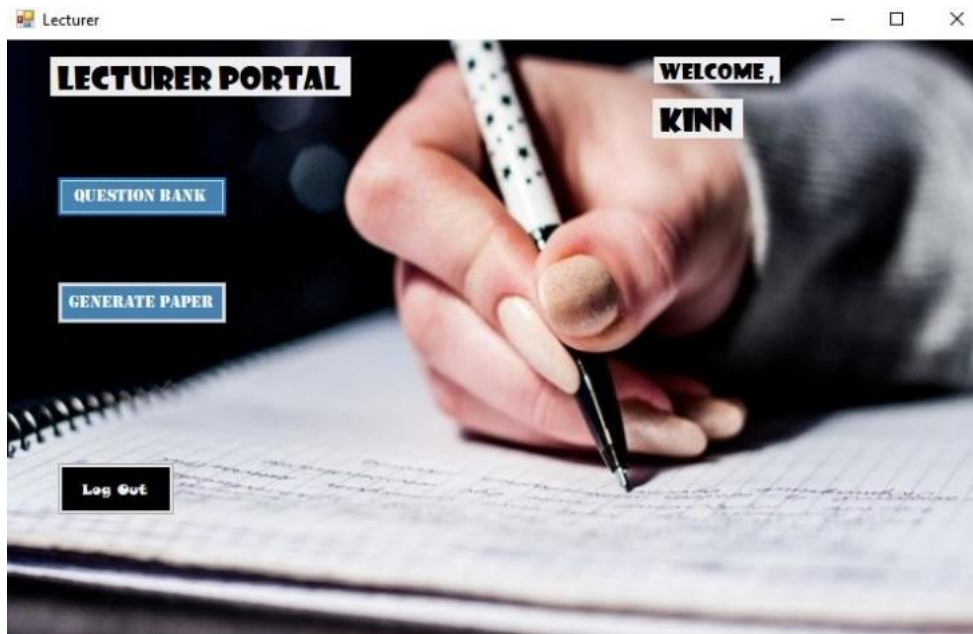If authentication as a lecturer role is successful, user accesses Lecturer Portal.

Figure 13. Lecturer Portal interface.

Here Lecturer can do two main tasks:

(1) "Add question": lecturer can key in question together with answers and save the content into question bank database. To switch between question types, Lecturer has to close current question form and go back to Lecturer Portal form.

Figure 14. Lecturer Portal: Add Question forms – MCQ, True/False, Open-Ended.

(2) "Generate Paper": Lecturer should choose the subject, then click "Generate" and the created paper will be displayed in the form. AQPGS locates all the questions under respective subject and question types and then generates specified number of questions for each section. Currently the design includes: 10 multiple choice and 10 true/false questions under section A, 3 questions under section B and 2 questions under section C.

Figure 15. Generated question paper.

AQPG system retrieves questions from question bank using randomization algorithm based on question ID for all three sections. However, in sections B and C mapping function based on keywords is added to algorithm. Every word in questions' content is compared against specified Bloom's Taxonomy categorization verbs acting as query keywords. If any question contains a verb matched as the specified keyword, it is placed in the respective section based on complexity level, where section C questions are most complex ones. This process is performed until the specified set of questions is retrieved and final resultant string is sent to the application form together with its respective question. Upon clicking "Export" button, Lecturer is able to download generated question paper with all its details (answer options and instructions) in MS Word format or click "Cancel" to abort generation.

6.   Conclusion and future enhancement

6.1. Conclusion.

This study involved overview of the assessment process and Bloom's Taxonomy; discussed advantages of information systems in assessment and several assessment generation systems were evaluated. As well, survey was conducted to collect data from FTMS academics to determine the issues and develop more efficient alternative. Automated system prototype was developed as a basic desktop application in Visual Studio environment with functions such as secure login, question bank and generation algorithm to serve the main purpose of speedy design of question papers aligned with learning outcomes based on Bloom's Taxonomy hierarchy.

In regards with to problems identified with current manual system, automatic system prototype provides following solutions: (1) Significantly reduces human involvement by processes automation; (2) Helps retain resources by performing tireless rigorous work of information processing, hence instructors can focus more on academic part rather than devote much time to question papers design; (3) System allows for rapid data retrieval and manipulations to generate output on the click with minimum effort; (4) Robust algorithm provides unbiased results due to random selection of questions and eliminates duplications; (5) System offers concise storage of question items, question bank can cover wide range of subjects and question types.

The researchers hereby conclude that the proposed solution was helpful as alternative to present practice. However to be fully functional, it may need improvement, as current prototype has the following constraints: (1) System must be given accurate inputs, otherwise it may produce incorrect results; (2) User has to format the question paper after it's prepared; (3) Lecturer has to manually update information by entering new questions into database; (4) Admin has to change paper structure every time lecturer wants to change paper format.

6.2. Future enhancement.

Current project is basic application prototype to demonstrate the idea and prove usefulness of automatic system through development of mapping and randomization algorithm to facilitate human labor and eliminate errors in question paper generation process. In order to further extend its functionality, following enhancements may be done: (1) System to be re-designed into web-based application using PHP programming, Javascript and SQL server database, to be more interactive, secure and provide opportunity to display previous question papers online for students' reference and online quizzes; (2) Function to scan input and convert it into text to save multiple questions at a time; (3) Integrated spelling and grammar check to eliminate any human errors in input; (4) Check for any repeated questions to avoid duplications; (5) Multi-language support; (6) Integrated compliance with MQA; (7) Automatic paper grading based on given criteria; (8) Option to change paper format by Lecturer without reference to Admin; (9) More output format options such as MS Excel.

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