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An Application of Bloom's Taxanomy in Generation and Assessment of Examination Question Items

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***Abstract*— The objective of this development research is to explore the application of Bloom's Taxanomy in the generation of examination question items process. In addition, assessment of the item's complexity will also be addressed. This paper provides the explanation, description and information about the Generation and Assessment of Examination Question (GAEQ) for the use of the lecturers in higher learning institute. The current process to generate the examination questions and assess their complexity is done separately and manually. The contribution of this paper is the integration of Bloom's Cognitive Domain in both generating and assessing the examination question. The assessment process will automatically measure the complexity level of the question items. GAEQ will then compile those items and create a complete final examination question set. Hence, it is the aim of the GAEQ system to initiate and develop a system to assist the lecturers in producing quality examination questions.**

Keywords — Assessment, Bloom's Taxanomy, derivation of examination question.

I. INTRODUCTION

As we encounter a new era of technology, computerized and automated tools are desirable because of its ability to overcome the drawbacks conventional methods that require a lot of effort and also to provide convenience to users. In facilitating the education domain, we propose to design and develop a new assessment system i.e. Generation and Assessment of Examination Question System (GAEQ). The system shall be able to generate final examination question and assess the question items' complexities based on Bloom's Cognitive Domain [1]. The keywords or terms contained in the cognitive domain are categorized according to six types of difficulty or complexity levels from the easiest to the most complex i.e knowledge, comprehension, application, analysis, synthesis and evaluation [3].

Importantly, since the GAEQ system complexity assessment method is based on syntactic, the system is working on three types (formats) of question which are (1) Multiple Choices Question (MCQ), (2) True False Question (TF) and Essay Question. In contrast, the system cannot work on the Fill-In-The-Blank (FIB) question and it will be described later in the system scope.

II. PROBLEM STATEMENTS

In the current scenario, lecturers manually create examination questions, and the process of assessing the questions complexity is done separately. Therefore, the separate processes cause the lecturers to undergo two different workflows to complete an examination paper. In addition, lecturer must manually refer to Bloom's Cognitive Domain reference to assess the complexity level of the question items. These processes require dedicated effort and time. From this situation, two methods of creating examination question are identified; i.e. (1) the creation of the questions paper and (2) the assessment of the questions complexity. In the current process of creating the final examination paper, lecturers will conduct several preparations such as specifying the topics, formatting the question structure and creating the question items. Subsequently, lecturers will compile the question items into the final question paper. In the future, if they want to repeat or reuse the same questions, they have to manually find the questions the previous final question papers and manually compile them into a new question paper. Hence, it will lead to inefficiency due to unnecessary efforts.

III. Research Objectives

The main objective of this work is to integrate Bloom's Cognitive Domain in the processes of generation and assessment of examination questions. The objectives of the GAEQ system are:

1. To create a convenient mechanism for examination questions production by integrating the generation and assessment methods.
2. To automatically measure the complexity level of question items based on the syntactic view.

IV. Scope of the System

The GAEQ system is a new platform of integration between examination question generation and complexity assessment. Both elements are combined in order to assist lecturers to create final examination question paper. The roles of this system are (1) the administrator and (2) the lecturers at higher learning institution.

For example, as a lecturer, he shall be able to register to the system. Whilst, an administrator shall be able access to the system to activate or approve the newly registered lecturer so that the lecturer can use the system functionalities as intended. Furthermore, as the main part of the system functionality, the lecturer can create a question item and then measure the item's complexity level according to Bloom's Taxonomy. Moreover, he can also select and compile the question items to generate final examination question paper.

To support the confidentiality of the question items, the system administrator has no privilege of accessing the question items. Hence, only the lecturer who creates the items can view or modify them, including the complete final examination paper.

In addition, the scope of assessment is based only on the syntactic view, hence, only MCQ, TF question and Essay question can be used to measure its complexity levels. The assessment excludes the Fill-in-the-Blank (FIB) questions because most of the keywords used in the construction of the FIB questions are not defined in the Bloom's Taxanomy.

For example:

1. What are the examples of unconditionally secure cipher?
    (a) One Time Pad
    (b) Caesar
    (c) AES
    (d) DES
2. Analyze the processes involved in Reversed Engineering. Please provide an example.

For example (1), the MCQ type question, its complexity level will be assessed based on the word `what` used in the question ietm. The `what` keyword is categorized as the easiest level of complexity, which is the Knowledge (Level 1). For the subsequent example, which is the Essay question, the word used is `analyze`. Hence, the complexity level of the question is categorized as moderate level, which is Analysis (Level 4).

Because the work depends on syntactic detection, the types of the question do not affect the complexity assessment method, but the use of keywords is the main focus. In is crucial to point out that for the FIB type of question, the question statements are normally too broad. Thus, the use of the predefined terms[1] is not applicable to be used. The FIB question might be presented as completing facts or filling in a missing word in a statement. Thus, the scope of this work does not cover FIB question items.

After the process of generating the examination question, the process of storing and retrieving the generated question sets are beyond the scope of this research.

V. Literature Review

The literature review section lays out the investigation of (1) Bloom's Cognitive Domain in the process of generation and assessment of examination questions; and (2) applications of the Bloom's Cognitive Domain in the literature.

A. Cognitive Domain of Bloom's Taxanomy

In [3], Bloom's Taxonomy is a tool of learning objectives for education proposed by committees of educators under the leadership of educational psychologist named Benjamin Bloom. It was initially designed to improve communication between educators on the design of curricula and examinations [2]. The aim of this learning means is to promote higher forms of thinking in education, such as analyzing and evaluating, rather than just remembering facts. Throughout the conference and meeting in 1956 [1], the committees came up with the classification of Bloom' s Taxonomy domains, these domains are categorized into three parts:

1. Cognitive Domain
2. Affective Domain
3. Psychomotor Domain

For cognitive domain, according to Bloom [3], it involves knowledge and the development of intellectual skills. This includes some activities such as the recall or recognition of facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills. According to the domain levels, it begins from the easiest level up to the most difficult level. That is, the first level must normally be mastered before the next ones can be taken place. As our focus is the Cognitive Domain[2], GAEQ will implement a complexity assessment mechanism through the syntactic detection. Based on the mechanism, it will measure the complexity based on the words used the question items. Hence, the words used must be derived from 6 Cognitive Levels. In addition, for each level, the system will set a measurement value[3]. Below are Table I and Table II for the cognitive domain and the measurement value respectively.

TABLE I. Levels of Cognitive Domains

[1] The predefined terms mean the terms or words which are listed in the Bloom's Taxanomy.
[2] The complete keywords list of Bloom Taxonomy's Cognitive Domain is not provided in this paper.
[3] The measurement values defined by the project team.

Levels	Words	
Knowledge *Recall data or information.*	Define Describe List	Name Show When
Comprehension *Demonstrate understanding of facts and ideas.*	Explain Describe Interpret	Ask Cite Infer
Application *Using new knowledge.*	Apply Calculate Complete	Solve Use How
Analysis *Examine and break information into parts.*	Arrange Classify Why	Analyze Infer Connect
Synthesis *Compile information together.*	Construct Create Design	Develop Prepare Imagine
Evaluation *Present opinions by making judgments.*	Appraise Assess Evaluate	Test Justify Support

TABLE II. MEASUREMENT VALUES

Category	Level	Measurement Value
Knowledge	1	Easiest
Comprehension	2	Easy
Application	3	Moderate

B. Application of Bloom's Taxanomy

A few research works have been investigated. In [7], the researchers applied the Bloom's Cognitive Domain in their e-learning assessment method for form 4 students at a local secondary school. Nonetheless, the categorization of the keywords in Bloom's level is manually done by the instructor and later be verified by an expert panel. In our work, the keywords are automatically detected and categorized by the tool during construction of the question items.

In work such as [4] and [5], Bloom's Cognitive Domain have been applied in assessment of biology course for undergraduate students. In [4], learning activities can be supported by individual and group activities in order to achieve certain levels of Bloom's Taxanomy. In this work, the outcome i.e. the assessment tool based on the Bloom's Taxanomy is intended to guide and enhance the learning process of the biology course. There is no implementation of the applied assessment tool in the context of automated question items generation.

C. Application forAutomated Assessment Generation

The current trend in education is to adopt applications that are able to assist in managing and handling the main business tasks i.e. including automated generation of assessment items. Applications such as Moodle[4] and Claroline[5], are examples of open-source learning management system. Although these applications support the feature of assessment generation, nonetheless, no specific backbone is implemented specifically for the assessment feature. These applications are in fact, are designed in such a way that it is generic and can be customized according to the intended users' needs.

[4] Can be retrieved at https://moodle.org/

[5] Is available at http://www.claroline.net

VI. RESEARCH METHODOLOGY

The research consists of five stages, (1) Planning, (2) Analysis, (3) Design, (4) Implementation and (5) Testing. The following subsections describe each of the stages. In the end, a prototype is developed as a proof-of-concept of the application of the taxonomy in automated generation of the assessment items.

A. Planning

Planning is established to set up the goals and objectives of the research. Several steps have been taken to accomplish the project plan such as creating Gantt Chart, Context Diagram[6], the project objectives and scope, programming languages, tools and database management system for the prototype development.

B. Requirements Analysis

This phase identifies the system requirements and evaluates the feasibility of the system. Figure 1 depicts the context diagram of the proposed system. The main purpose of this phase is to collect, define and validate functional and non-functional requirements[7] [6].

The requirements analysis is performed by reviewing the current process of generating final examination questions via the IIUM Management and Implementation of Policies and Procedures on Preparation of Final Examination Question Paper[8]. Hence, we found out the procedures to create the final examination questions and identify the use of Bloom's Taxanomy in the assessment process. As a result, we managed to define several basic requirements of system application and significant requirements for the processes.

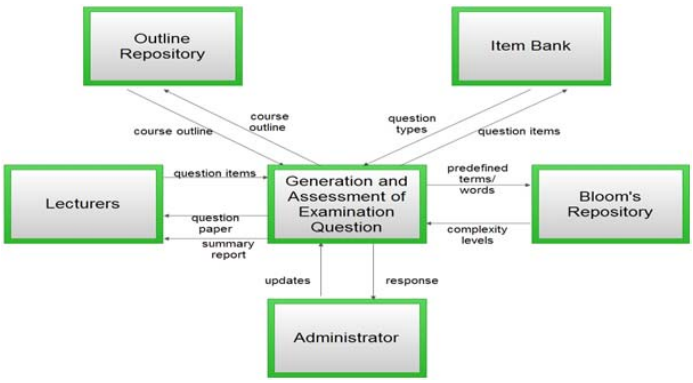


Fig. 1. GAEQ Context Diagram

In order to validate those defined requirements, an interview with Assoc. Prof. Dr. Ainol Mardziah, the Deputy Dean of Academic Affairs of Institute of Education IIUM was arranged. The interview discussed the current method to

[6] For the planning phase, a Gantt Chart was developed.

[7] The functional and non-functional requirements document together with the Use Case Narrative were included in the final report.

[8] The Implementation of Policies and Procedures and the interview question were referred to.

assess the question complexity and the process to generate final examination question.

As the outcomes of the interview, most of the defined requirements were feasible, as we found out that there are no computerized system to integrate the assessment and generation of examination questions in IIUM. It is pertinent to note that, as our core assessment method uses syntactic detection, we made a study on Bloom's Taxonomy as it is the core knowledge of our system. From this study, we identified the keywords used in the domain and its levels, as described in the literature review.

As a result, we described the processes of the system through the Activity Diagram[9] as shown in Fig. 2. The figure depicts the flow of processes involved in deriving, generating and assessing the question examination.

C. System Design

After the requirements were gathered, the necessary specifications for the hardware, software, people, data resources, the information products that will satisfy the functional requirements of the proposed system, were determined. The designs such as Entity Relationship Diagram (ERD) and Interface Design[10] serve as blueprints for the system and help to detect and correct any errors or problems, which are built into the final system. In addition, all the designs created were based on the defined requirements. As the system prototype development worked iteratively, modification or improvement in system design were performed several times in respect to the changes in requirements and implementation stage.

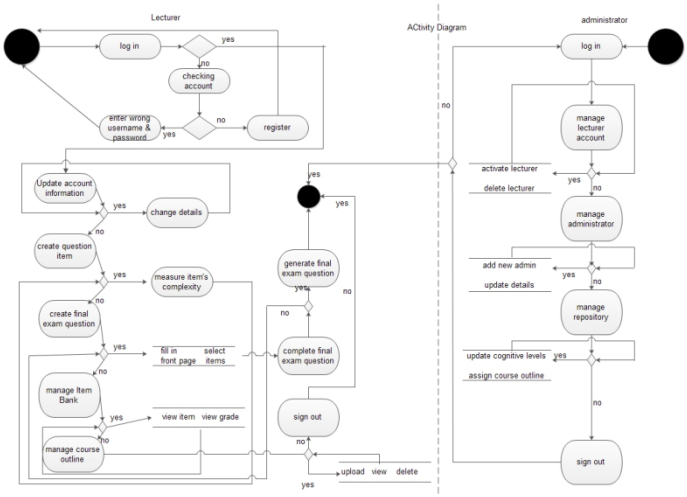


Fig. 2. GAEQ Activity Diagram

In addition, we also provided the architecture design for the GAEQ system (see Fig. 3). The system were designed as a three-tier architecture, in which we allocated presentation, application and data layers. The application layer provides the business logics which are relevant to the adoption of the Bloom's Taxanomy. The data layers store and manage the databases for the system including databases for academic staff, administrator, courses and assessment items.

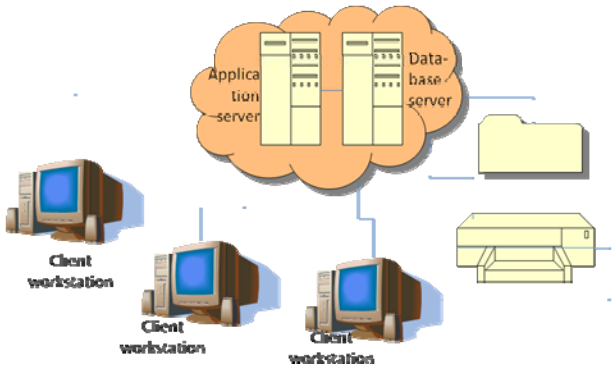


Fig. 3. GAEQ Architecture Design

D. Implementation and Development

Once the design is documented, all the system functionalities and database were built. Some of the challenges during this stage were requirements changes from the previous stages. During implementation, we made a review and research on the main technical programming implementation such as data retrieval, session, and conversion to PDF format using TCPDF class. In addition, we made a research on searching method such as string matching to apply in our complexity assessment method.

The implementation languages for this project are Hypertext Markup Language (HTML), Hypertext Preprocessor (PHP), with the support of Cascading Style Sheets (CSS) and JavaScript. For the database management system, MySQL is used as the main framework to create, maintain and store all the data required for this system.

The implementation adopts Adobe Dreamweaver CS5 for the interface design. For the server, we use phpMyAdmin Version 3.5.4. The GAEQ system is best viewed using Google Chrome 17 and above.

VII. System Requirements

This section briefly explains about the functional and non-functional requirements of the system. Functional requirements were gathered during the project analysis phase and were documented to guide the later stages i.e. design, implementation and testing stages. For non-functional requirements, they will not be described here. The functional requirements of the GAEQ system are clearly according to two actors, which are the lecturer and the administrator. Each of them has their own interests and roles towards the system. Figure 4 illustrates the use case of the GAEQ system. It specifies the functions that can be performed by the main two actors i.e. administrator and lecturers.

[9] The description of the Activity Diagram was provided in the final report.

[10] The ERD and Interface Design were included in the final report.

The detailed functional requirements are provided in Appendix A.

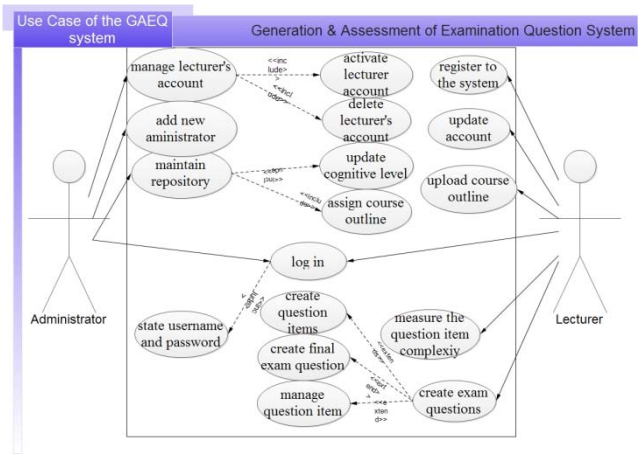


Fig. 4. Current scenario

VIII. Evaluation

The evaluation of the prototype was performed at IIUM. In order to evaluate the prototype, the constant self-tests were made for every versions of the created prototype. This is to ensure the compliance of functional requirements. Nonetheless, for some cases, once the early prototype was produced, we found out that some unimportant requirements could be removed. In contrast, missing requirements were added.

For the result, it describes the accomplishment of the system development. An example of the creation process of a MCQ question item is shown in Fig. 5.

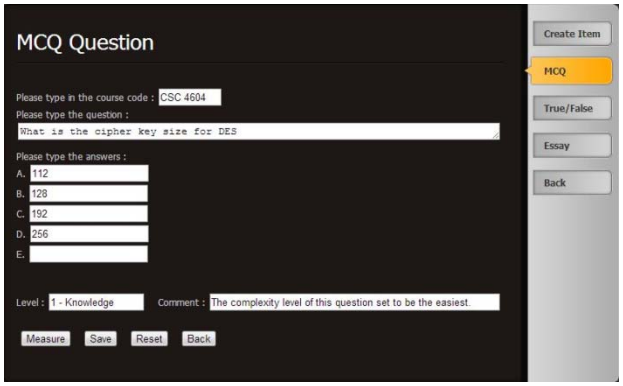


Fig. 5. The Question Item

As we can see, a lecturer shall be able to specify the course code of the course, the question with the answer. Then he shall be able to measure the item complexity by clicking the `Measure` button, and as a result, the system will produce the complexity level and its measurement value. Once the assessment is complete, he shall be able to store the item in the Item Bank.

For testing, a set of Test Cases[11] were created to test the main functional requirements, which are the complexity assessment and the question generation. In this paper, we provide one example of a test case for the creation of an assessment item. See Table III.

TABLE III. Test Case for Create Question Item

5	Test Case : Create Question Item Module			
Step	**Step Description**	**Expected Result**	**Related Requirement**	**Remark**
1	Click the 'Create Item' module. Then, click 'Enter' in the description part.	Lecturer will be directed to the categories of question format (MCQ, True False and Essay questions).	CNQIM 5.1	Passed
2	Select question format.	Example: MCQ. Lecturer will be directed to the MCQ Question for Item's Creation.	CNQIM 5.1	Passed
3	Type in the course code of the related course/subject in the 'Course Code' form.	Example: CSC 4032. The course code entered.	CNQIM 5.1	Passed
4	Type in the question item in the 'Please type the question' form.	Example: What is the number of round operation of DES? A.112 B.128 C.192 D.256 The question is entered.	CNQIM 5.1	Passed
5	Measure the question item's complexity by clicking the 'Measure' button.	The system will give the complexity level in the 'Level' form and description of the measurement/assessment in the 'Comment' form.	CNQIM 5.3 CNQIM 5.5 CNQIM 5.6	Passed
6	Store the question item in the Item Bank by clicking the 'Save' button.	Item stored.	CNQIM 5.2 CNQIM 5.6	Passed

Figure 6 illustrates the sample of generated final examination question paper for MCQ part. Briefly, a lecturer shall be able to select the question items in the Item Bank. After selecting the question items, now they are ready to be generated into final examination question paper in PDF format.

SECTION A : MCQ (10 marks)
Fill the answer in the booklet provided.

1. What is the cipher key size for DES?
A) 112
B) 128
C) 192
D) 256

2. Define the steps in trivium, modern stream cipher.
A) Initialization
B) Warm up
C) Encryption
D) All the above

3. Name characteristic of One time pad.
A) Key length must same as the plaitext
B) The key must be random generated
C) The key can be used once
D) All the above

Fig. 6. Generated question paper

As one of the GAEQ system requirements, it should also generate the front page of the examination question paper. The lecturer shall provide the details of the examination such as date, time, duration, semester details and eventually GAEQ shall be able to generate such cover page as shown in Fig. 7.

[11] All the other Test Cases are included in the final report.

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

END-OF-SEMESTER EXAMINATION
SEMESTER 2, 2012/2013 SESSION

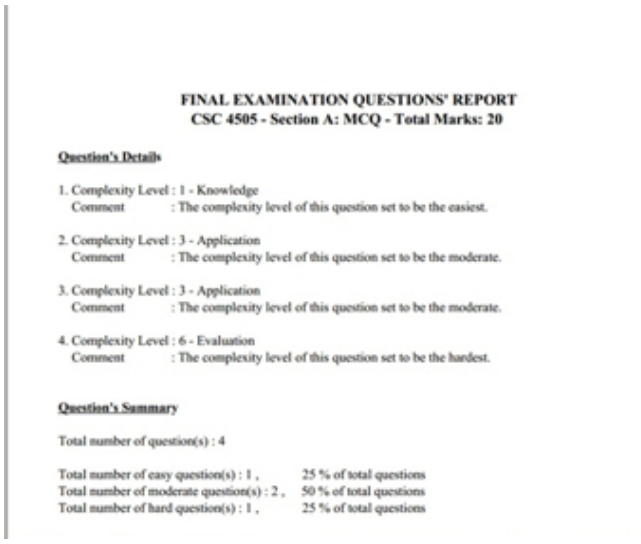
KULLIYYAH OF INFORMATION AND COMMUNICATION TECHNOLOGY

Programme	: Computer Science	Level Of Study	: Undergraduate
Time	: 9.00AM - 11.30AM	Date	: 17 May 2013
Duration	: 2.5 hours	Section	: All
Course Code	: CSC 4505		
Course Title	: Software Testing		

Fig. 7. Generated Front Cover Page

In addition, he shall be able to view the summary or report that lists the difficulty level of each question item and rates their percentage according to the sections (MCQ, True False and Essay sections). The summary outlines the percentage according to easy, moderate and hard levels.

A sample of the assessment of the question items is shown in Fig. 8.



FINAL EXAMINATION QUESTIONS' REPORT
CSC 4505 - Section A: MCQ - Total Marks: 20

Question's Details

1. Complexity Level : 1 - Knowledge
   Comment : The complexity level of this question set to be the easiest.

2. Complexity Level : 3 - Application
   Comment : The complexity level of this question set to be the moderate.

3. Complexity Level : 3 - Application
   Comment : The complexity level of this question set to be the moderate.

4. Complexity Level : 6 - Evaluation
   Comment : The complexity level of this question set to be the hardest.

Question's Summary

Total number of question(s) : 4

Total number of easy question(s) : 1 , 25 % of total questions
Total number of moderate question(s) : 2 , 50 % of total questions
Total number of hard question(s) : 1 , 25 % of total questions

Fig. 8. Generated Summary of the Question Paper Assessment

A working prototype is accessible at http://gaeq.podserver.info/[12].

IX. Discussion

In reflection to our objectives, we have fulfilled all the requirements and importantly we managed to achieve our objectives. Firstly, we managed to integrate two methods of generation and assessment of examination question items. Hence, the lecturers can have a system to create and generate question items.

[12] Please contact the authors if you are not able to access this site.

Secondly, the system will automatically measure or assess the question items' complexities. This way, the complexity result or the assessment value will be given and stored for each of the item for future reuse purpose.

Besides that, the system also has some constraints. Firstly, as mentioned in the result section, the summary that outlines the difficulty levels and the percentage is generated according to the question types. Therefore, in order to get a total percentage of the whole paper, the lecturers have to do it manually.

Secondly, as stated in the requirements, the system has the course outline functionality. The actions that can be performed by the lecturers concerning the course outline are viewing, uploading and deleting. Hence, the course outline acts as a reference for the lecturers to review the course topics and syllabus before creating the question items.

Thirdly, the system assessment method can be performed to all question types except for FIB Question as described in the system scope section.

X. Conclusion

GAEQ system initiates a significant medium to integrate two different conventional methods in examination question production i.e. the generation and the assessment methods. The significant properties of the resarch are to integrate the Bloom Taxanomy Cognitive Domain in the production of examination question items and to automate the complexity result of question items. Consequently, this processes support the academics in their preparation of examination questions.

A possible future work is to enhance the assessment of the question item's complexity based on the semantic instead of syntactic only. Indeed, in order to so, a comprehensive and detailed research is required because of the complexity of the problem to be understood, analyzed, tested and implemented. Nonetheless, having an intelligent algorithm that can detect the complexity of the question item is desirable.

Acknowledgment

The authors would like to express our gratitude to Assoc. Prof. Dr. Ainol Mardziah, Deputy Dean of Academic Affairs of Institute of Education IIUM for her willingness to participate in the requirements elicitation process.

Appendix A: GAEQ Functional Requirements

Functional requirements are specified and documented to lead the system blueprints because all the system modules (functionalities), database and interfaces are designed according to the specified requirements. In addition, testing will be designed and performed based on these documented requirements.

Below are the lists of the system functional requirements sorted according to the main modules.

System Main Modules:

1. Register Module (RM)

1.1 RM shall allow first time lecturer to register to the system by providing personal information such as:
- Full Name
- Staff Id
- Email(IIUM email)
- Password
- Secret Question
- The Answer of the Secret Question

2. Login Module (LM)

2.1 LM shall allow the users to login to the system by providing email and password.
2.2 LM shall allow the users to recover password if forgotten.
2.3 LM shall allow the users to log in as appropriate user, whether as Administrator or Lecturer.

3. Forgot Password Module (FPM)

3.1 FPM shall allow the users to retrieve the password.
3.2 User must enter a username and fill the secret question with the answer that they provided during registration to retrieve the password.

4. Update Account Module (UAM)

4.1 UAM shall allow the users to update their account information (* lecturer cannot change the username as it is a primary key in the Lecturer Database).
4.2 UAM shall allow the userto change their password.

5. Create Question Item Module (CNQIM)

5.1 CNQIM shall allow the lecturer to create the question items one-by-one by selecting it in several types which are:
- Multiple Choice Question
- True False Question
- Essay Question

5.2 CNQIM shall allow the lecturer to store the question items into the Question Bank.
5.3 CNQIM shall allow the lecturer to measure the question items complexity once the question fully stated.
5.4 CNQIM shall allow the lecturer to reword the question item if the term entered does not match with the predefined term.
5.5 CNQIM shall the system to give the measurement description for the assessed item.
5.6 The result of complexity level shall be incorporated with the question items and stored into the Question Bank.

6. Create Final Question Module (CCQM)

6.1 CFQM shall allow the lecturer to create/generate the completed final questions paper.
6.2 CFQM shall allow the lecturer to fill up the front page of the completed final paper with several information (programme, date, time, duration, course code, course title, section, level of study and students' details).
6.3 CFQM shall allow the lecturer to select question items according to the question types to create completed final questions.
6.4 CFQM shall allow the lecturer to generate a summary report of generated question paper for each section of the paper.

7. Outline Repository Module (ORM)

7.1 ORM shall store the course outline document for each subject.
7.2 ORM shall allow administrator to assign certain course taught by the lecturers by listing down the course outline information (course title, course code and lecturer's username).
7.3 ORM shall allow administrator to remove the course outline information.
7.4 ORM shall allow the lecturer to upload, download (to view) and delete course outline document according to the subjects assigned by the administrator.

8. Item Bank Module (ARM)

8.1 IBM shall allow the lecturer to view the questions item with the complexity level.
8.2 IBM shall allow the lecturer to delete the question item.

9. Manage Lecturer Module (MLM)

9.1 MLM shall allow the system administrator to respond to the newly registered lecturers by activating their account:
- One-by-one account activated
- All account activated

9.2 MLM shall allow the administrator to remove the lecturer's account one-by-one.

10. Manage Administrator Module (MAM)

10.1 MAM shall allow the administrator to add another new administrator to run the system by entering the information of the new administrator:
- Username
- Full Name
- Email
- Phone Number
- Password

10.2 MAM shall allow the administrator to remove another administrator.

11. Bloom's Module (BM)

11.1 BM shall allow the administrator to add new words or remove any word in the Bloom's Repository.

11.2 BM shall allow the lecturers to view the predefined words/terms in the Bloom's Repository.

REFERENCES

[1] Anderson, L. W., and Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives. New York: Longman.

[2] Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R. and Wittrock, M. C. (2000). A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, Abridged Edition (2nd ed.). Allyn & Bacon.

[3] Bloom, B. S. (1956). Taxonomy of educational objectives: the classification of educational goals. D. McKay.

[4] Crowe, A., Dirks, C., and Wenderoth, M. P. (2008). Biology in Bloom: Implementing Bloom's Taxonomy to Enhance Student Learning in Biology. CBE-Life Sciences Education, 7(4), 368–381. doi:10.1187/cbe.08-05-0024.

[5] Hoskinson, A.-M., Caballero, M. D., and Knight, J. K. (2013). How Can We Improve Problem Solving in Undergraduate Biology? Applying Lessons from 30 Years of Physics Education Research. Cell Biology Education, 12(2), 153–161. doi:10.1187/cbe.12-09-0149.

[6] Kotonya, G., and Sommerville, I. (1998). Requirements engineering: processes and techniques. Chichester; New York: J. Wiley.

[7] Rahmat, M., and Saudi, M. M. (2007). E-learning assessment application based on bloom taxonomy. The International Journal of Learning, 14(9), 1–12.