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Automated Test Paper Generation Using Utility Based Agent and Shuffling Algorithm

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ABSTRACT

This article describes how with the advent of computer-based technology, there is movement from manual to automated systems for different aspects of the education system. Testing is an essential part of teaching process that helps academics in classifying the level of students and evaluating the outcomes of their teaching process. The testing process requires a large amount of attention and professionalism. Automated Test Paper Generation is a system applying the shuffling algorithm in designing different sets of questions without repetition and duplication. It helps the faculty in developing and designing exams with a particular level of difficulty required in evaluating the students by using the utility-based agent. The system includes a knowledge base of many questions' types that are linked to a test engine where the faculty can specify the type and the difficulty level of the exam and then the system will assemble the exam and produce the output as electronic or paper-based. Questions will be picked randomly from the knowledge database. This automated system provides cost saving and time efficient solutions.

KEYWORDS

Automated Software, Knowledge Base, Shuffling Algorithm, Test Paper Generation, Utility-Based Agent

1. INTRODUCTION

Many problems facing exam designing process, the necessity to solve this is the authors' main motivation in developing this system. The most important one in that the process of designing exam papers is a redundant and very time-consuming process that will take place many times during each semester, which forms a challenge to the examiner especially with all other commitments. Also, exam design process requires experience and many examiners face problems in adjusting the difficulty level of the exam for the different sections of the same course which cause fairness problems. And for examiners with little experience formatting the question structure is very difficult. The necessity to change and update the question knowledge bases to guarantee versatilities is very important for examiners and the process of keeping old questions registered to avoid redundancy is a very important task. The storing and utilization of generating work by adding all new updated and modified questions to questions knowledge base and will help saving organization experience and knowledge. Researchers

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noticed that some of the available literature reviews and research focus on shuffle algorithm and other research focus on the utility based agent. This research contributes to the body of knowledge is combined both utility-based agent and shuffling algorithm for test paper generation.

1.1. Proposed Solution

To solve above problems, we need to develop a test paper generation system that is linked to questions knowledge base. The examiners will log into the system, specify the question type and the difficulty level and other required attributes, and then the system will automatically assemble the exam paper which will save the time and effort of the examiner and enhance standards and unified the level of difficulty between different sections. So, this application aims to help examiners, faculty members in particular in one of the most important tasks in education and training environment by providing them with a well-designed, secure way to create exams. The system aims to develop a test paper generation system for colleges at Princess Nourah bint Abdulrahman University (PNU), in the future; it will be for examiners in general (Universities, Schools, and examiners in Training and Educational centers). It aims to achieve the following objectives:

- Reduce the time, which allocated for testing the generation process by providing an automatic way to accomplish the task.
- Help examiners in choosing the appropriate level of difficulty and unify it through the exam.
- Help to avoid redundancies by keeping a record of recently-chosen questions.
- Provide a unified tool for all educators to achieve consistency.
- Provide a secured tool that chooses randomly from a vast question knowledge base.
- Ensure is more complying with educational standards by providing versatile types of questions that can be chosen according to the required test type.

2. BACKGROUND INFORMATION

The test development process is a very critical task in the educational environment that should guarantee comprehensiveness and accuracy and should cover all parts of the courses. Exams include different types of questions and mean to test knowledge and skills. In the e-learning context, one of the indispensable components is the E-test system involving test generation, delivery, evaluation, and results publishing (Hua & Hairui, 2008). Questions are useful and used to recognize any deficits in the learner's knowledge and enhance the learning process and outcomes. In Automatic Question Generation (AQG) field, most of AQG systems focus on the text-to-question task, where a set of content-related questions are generated based on a given text. Usually, the answers to the generated questions are contained in the text (Ci & O'Farrell, n.d.).

2.1. General Test Items Categories

- **Objective Items:** Require students to select the correct response from several alternatives or to supply a word or short phrase to answer a question or complete a statement (Liu, et al., 2010).
- **Subjective or Essay Items:** Permit the student to organize and present an original answer. Objective items include multiple-choice, true-false, matching and completion, while subjective items include a short-answer essay, extended response essay, and problem-solving and performance test items (Liu et al., 2010).

2.1.1. Exams Preparation Issues

To prepare Exams, the following specific and accurate steps are needed (Center for Innovation in Teaching and Learning, n.d.):

- Choose the exam format and the question type that will help the examiner to measure the performance and skills of the examined students.
- The exam should serve the course objectives and learning outcomes and specify which aspects the exam will include before designing the exam.
- Questions should be written in a good, clear and unambiguous way to avoid any misunderstanding to help to achieve the learning outcomes. The instructor should write the questions and be sure that the student can perfectly understand what is required in the question.
- Write all the required instructions that should be applied by the students during the exam.
- The amount and difficulty of the exam should be suitable and aligned with the exam time allowed.

2.1.2. Exams Importance in Educational Process

Education involves intellectual training; it is the core of society and the individual and moral base of the modern organization which provides the individual with ways to be a good member and provides him with tools of innovation (Anaf & Sheppard, 2007). Examination history is too old, and it takes a lot of forms and techniques and became an important part of every academic process. Some of these major benefits are testing the learner's knowledge and allow learner and student to review the knowledge they gained during their study (V, 2002; Liu, et al., 2012).

2.2. Agent-Based Modeling (ABM)

A relatively new computational modeling paradigm for simulating the actions and interactions of autonomous agents is the modeling of phenomena as dynamical systems of interacting agents. Another name for ABM is individual-based modeling (Center for Innovation in Teaching and Learning, n.d.).

2.2.1. Agents

Agent-based models consist of agents that may be having different separated computer programs or parts of programs distinctly existed. Within a certain environment and they interact with each other by exchanging messages and information to each other and behave depending on this information which can reflect a level of learning (V, 2002).

2.2.1.1. Agents Types

- **Goal-Based Agents:** Knowing about the current state of the environment is not always enough to decide what to do. For example, at a road junction, the taxi can turn left, right, or go straight on. The right decision depends on where the taxis trying to get to. In other words, as well as a current state description, the agent needs some sort of goal information, which describes situations that are desirable, for example, being at the passenger's destination. The agent program can combine this with information about the results of possible actions (the same information as was used to update internal state in the reflex agent) in order to choose actions that achieve the goal (Russell & Norvig, 2010).
- **Utility-Based Agents:** Goal-based agents to distinguish between non-goal states and goal states. It is possible to define a measure of how desirable a particular state is. This measure can be obtained through the use of utility function that maps a state to a measure of the state utility. A utility-based agent has to model and keep track of its environment, tasks that have involved a great deal of research on perception, reasoning, representation, and learning (Russell & Norvig, 2010).
- **Interface Agents:** Interface agents are computer programs that employ Artificial Intelligence techniques in order to provide assistance to a user dealing with a particular computer application (Maes & Kozierok, 1993).
- **Mobile Agents:** Mobile agents are programs that can migrate from host to host in a network, at times and to places of their own choosing. The state of the running program is saved, transported

to the new host, and restored, allowing the program to continue where it left off. Mobile-agent systems differ from process migration systems in that the agents move when they choose, typically through a "jump" or "go" statement, whereas in a process migration system the system decides when and where to move the running process (typically to balance CPU load). Mobile agents differ from "applets", which are programs downloaded as the result of a user action, then executed from beginning to end on one host (Kotz & Gray, 1999).

- **Multi-Agent Systems:** Multi-Agent System (MAS) technology has impressively emerged as a new paradigm for software development. As autonomous software components, agents can interact through a standard protocol and collaborate with each other to achieve common goals. The MAS helps application designers to conceptualize solutions better: this paradigm may be more naturally suitable for certain types of applications; they can help improve code modularity and reusability; they can help hide network, system and protocol heterogeneity (Hua & Hairui, 2008).

3. TEST PAPER GENERATION ALGORITHMS

3.1. Utility-Based Agent

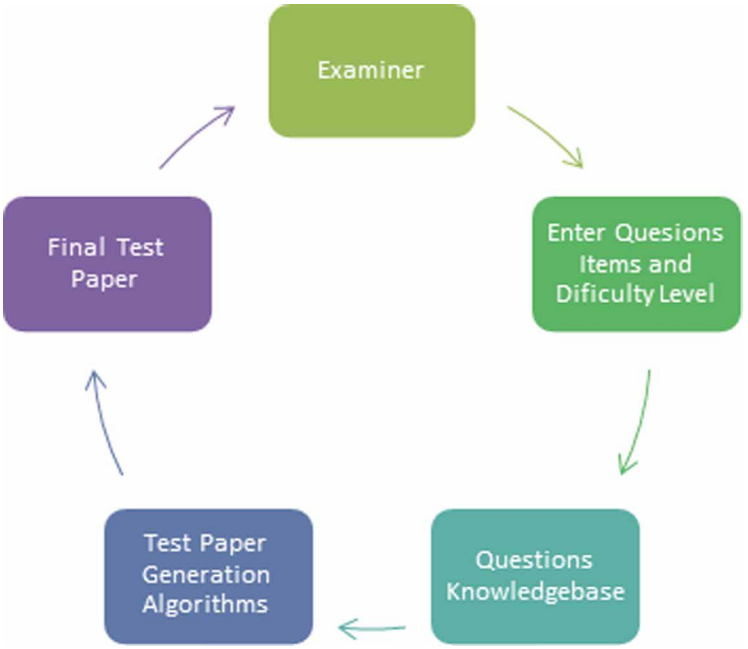
The idea of a utility function in goal-based agents provides a new paradigm for agent-based technology. This paradigm features proactive, reactive and autonomous behavior in achieving its goal and how well its goal is achieved. A utility function maps a set of states to the set of real numbers. In other words, given a particular state of the world, an agent is able to use its utility function to derive a score, or utility value that tells it how "happy" it is in that state or how successful it has been if it reaches that state. The utility-based agents are used to achieve its goals and to determine the measure of how efficiently the goal is achieved. The efficiency criteria can be any parameters that are wanted to achieve, in addition to the goal. Goals alone are not really enough to generate high-quality behavior. For example, there are many action sequences that will get the taxi to its destination, thereby achieving the goal, but some are quicker, safer, more reliable, or cheaper than others. The goals just provide a crude distinction between "happy" and "unhappy" states, whereas a more general performance measure should allow a comparison of different states (or sequences of states) according to exactly how happy they would make the agent if they could be achieved. Because "happy" does not sound very scientific, the customary terminology is to say that if one state is preferred to another, then it has higher utility for the agent (Russell & Norvig, 2010; Naz, Aslam, & Dar, 2010).

This paper aims to generate a test paper, but its difficulty level specifies what measure of difficulty we want to achieve. Furthermore, the usual benefits of agent technology like flexibility, usability, efficiency in terms of cost and time is also proposed by utility-based agents. The real strength of this algorithm is that it considers the difficulty level of questions at the time of test paper generation. The difficulty level assigned at the time of developing the knowledge base takes part in the absolute computation of entire difficulty level of test paper.

3.1.1. Modeling an Agent for Paper Generation System Using Utility-Based Agent

In this system, the test paper can be designed according to a specific level of difficulty, and the agents choose question items in such a way that the difficulty level of each question item takes part in computing the exact difficulty level of test paper as explained in Figure 1. In a test paper generator, we have to create a test knowledge base and assign each question a utility to specify the difficulty of the question when the user wants to create a test paper the examiner should choose the difficulty level for test paper. In turn, the utility-based test paper generation agent (on the behalf of the examiner) selects a question with utility value in such a way the total of utility value is equal to the required difficulty level. Later, a test paper is produced by a test paper generator according to difficulty level specified by the examiner (Herman, et al., 1990; Arshad, et al., 2012).

Figure 1. Utility-Based Agent



3.1.2. Utility-Based Agents Development Tools

Utility-based agents are goal based agents aiming to measure efficiency. In this paper, the major concern was to develop a web-based system to achieve the task. Some existing tools that provide reusable components for developing agents are ZEUS, agent Tool Project, Comet Way JAK. However, we adopt PHP, JavaScript and MySQL server for implementing the proposed system.

3.2. Shuffling Algorithm for Paper Test Generation

Shuffling algorithm is very suitable and effective method to implement for generating questions randomization. The strongest point of this algorithm is the ability to avoid redundancy and duplication in the exam papers and the randomization in the selection which will help in creating versatile copies (see Figure 2). For a set of TQ_KB (the total number of questions in the knowledge base) items for generating a random permutation of the numbers 1– TQ_KB, the behavior of the algorithm goes as follows in Algorithm 1 (Naik, et al., 2014; Jamai & Sultan 2010):

4. PROPOSED TEST PAPER GENERATION SYSTEM

This system is a web-based application system with several features mainly producing unduplicated sets of the exam paper and generating a test paper according to the chosen difficulty level. The steps to create an exam paper as follows (see Figure 3):

- The application primarily requires building a knowledge base of question items. Then, the examiner develops a knowledge base which enters the number of questions appearing on the test paper.
- Each test paper includes a different number of questions and each question has a difficulty level, which will be assigned an integer value from 0 to 5. Whereas the number in this range represents a particular utility value, the higher utility value means that the question is more difficult.

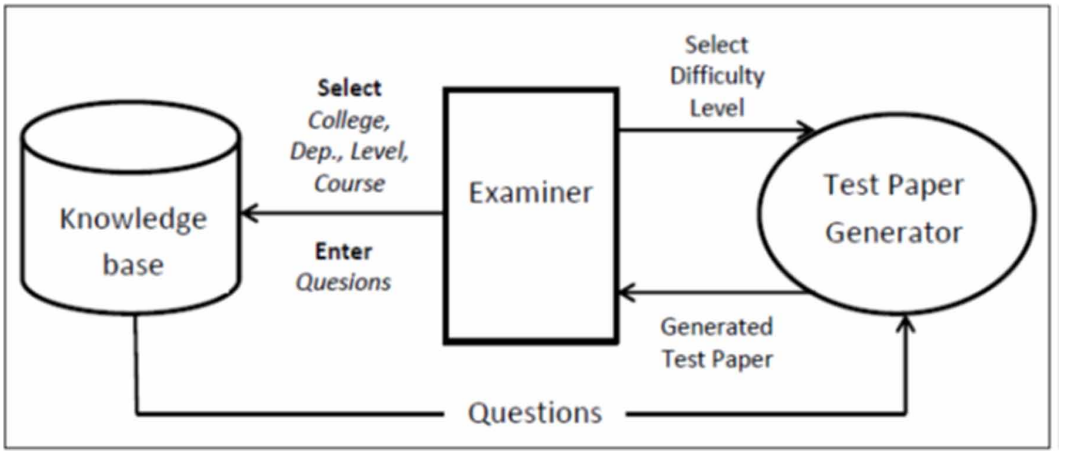
Figure 2. Randomization of questions selected using shuffling algorithm

		No of Question set									
		1	Status	2	Status	3	Status	4	Status	5	Status
Question Number	1	34		10		8		32		56	
	2	71	FALSE	37	FALSE	29	FALSE	51	FALSE	149	FALSE
	3	94	FALSE	78	FALSE	43	FALSE	89	FALSE	222	FALSE
	4	105	FALSE	121	FALSE	60	FALSE	116	FALSE	236	FALSE
	5	108	FALSE	635	FALSE	130	FALSE	138	FALSE	653	FALSE
	6	111	FALSE	705	FALSE	133	FALSE	202	FALSE	659	FALSE
	7	139	FALSE	736	FALSE	155	FALSE	212	FALSE	671	FALSE
	8	148	FALSE	754	FALSE	206	FALSE	224	FALSE	693	FALSE
	9	208	FALSE	755	FALSE	217	FALSE	619	FALSE	708	FALSE
	10	229	FALSE	1173	FALSE	640	FALSE	642	FALSE	747	FALSE
	11	652	FALSE	1203	FALSE	641	FALSE	675	FALSE	1162	FALSE
	12	701	FALSE	1213	FALSE	646	FALSE	691	FALSE	1200	FALSE
	13	758	FALSE	1255	FALSE	665	FALSE	704	FALSE	1202	FALSE
	14	764	FALSE	1260	FALSE	676	FALSE	761	FALSE	1222	FALSE
	15	778	FALSE	1262	FALSE	711	FALSE	788	FALSE	1233	FALSE
	16	1186	FALSE	1285	FALSE	768	FALSE	1176	FALSE	1236	FALSE
	17	1211	FALSE	1303	FALSE	782	FALSE	1179	FALSE	1248	FALSE
	18	1230	FALSE	1306	FALSE	789	FALSE	1196	FALSE	1305	FALSE
	19	1231	FALSE	1316	FALSE	1176	FALSE	1267	FALSE	1332	FALSE
	20	1274	FALSE	1317	FALSE	1198	FALSE	1298	FALSE	1707	FALSE
	21	1281	FALSE	1332	FALSE	1227	FALSE	1307	FALSE	1708	FALSE
	22	1290	FALSE	1702	FALSE	1231	FALSE	1334	FALSE	1733	FALSE
	23	1303	FALSE	1710	FALSE	1322	FALSE	1726	FALSE	1785	FALSE
	24	1304	FALSE	1736	FALSE	1717	FALSE	1767	FALSE	1787	FALSE
	25	1311	FALSE	1760	FALSE	1765	FALSE	1798	FALSE	1804	FALSE
	26	1316	FALSE	1765	FALSE	1815	FALSE	1817	FALSE	1815	FALSE
	27	1734	FALSE	1773	FALSE	1817	FALSE	1830	FALSE	1821	FALSE
	28	1771	FALSE	1789	FALSE	1825	FALSE	1861	FALSE	1847	FALSE
	29	1818	FALSE	1796	FALSE	1850	FALSE	1868	FALSE	1861	FALSE
	30	1880	FALSE	1858	FALSE	1859	FALSE	1879	FALSE	1878	FALSE

Algorithm 1. Behavior of the algorithm

1. Create an array of TQ_KB locations.
2. Generate a random number *k*.
3. *If (loc==0)*
   Store generated the number.
   else
   Compare the generated number with the previous number in the array.
   if matching value found,
   Go to step 2;
   else
   Store the no in next location.
4. Repeat step 2 for TQ_KB numbers.
5. Select questions from DB matching with values from array location one by one.

Figure 3. Test Paper Generation System



- Examiners are responsible for entering the required number of the questionable items in the knowledge base.
- The formula for computing required number of questionable items in the knowledge base is as in Equation (1):

$$TQ\_KB = TQ\_TP * N \quad (1)$$

- Where TQ_KB is the total number of questions required in the knowledge base, TQ_TP is the total number of questions required for test paper, and N is a number of utility values that can be assigned to any question where N ranges from 0-5.
- The examiner must enter values for a number of questions for any test paper not less than 20, and no limit for the maximum number of questions.
- The examiner has to choose the overall difficulty which is any value from 1 to 100%. This value is used in selecting these questionable items of computing the overall difficulty level given. Any question is chosen; it will be marked in a special field so it will not be repeated. Every time a question item is selected, the associated utility value is used in computing overall difficulty for test paper. The highest utility value of particular value is calculated as in Equation (2):

$$HU\_val = Dif\ \_\ level / I \quad (2)$$

I = Max. The value in the difficulty level range / Max. Utility value for states = 100 / 5 = 20

where HU_val is the highest utility value of test paper, Dif _ level is a difficulty level of this test paper, and I is the interval value for difficulty level after that the highest value is changed.

- Applying the shuffling algorithm to generate questions randomly.
- Two sets of question items are selected on the basis of utility value. The first set of the question items has HU_val. The second set of question items has HU_val - 1. The utility value of question items is used to compute the accumulative difficulty level of test paper.

5. SYSTEM ANALYSIS AND DESIGN

Information gathering techniques are very important by using appropriate tools, where the information is collected from the stakeholders to be used in requirements analysis. To collect the requirements in an efficient way we used a questionnaire to collect data from many users at the same time, the questionnaire questions are as follows:

Q1: How Many Times during the Semester You Prepare an Exam?
Q2: Do You Prepare the Exam by Yourself or Using Book Test Banks?
Q3: The Time Consumed to Prepare the Exam
Q4: Are you specifying the Difficulty of the Exam before Starting?
Q5: Do you prepare multiple Exam Copies with the Same Difficulty Level?
Q6: Are you repeating a Question more than One Time in Different Exams?
Q7: What is the difficulty of Preparing the Exams Process?
Q8: Are you utilizing External Resources in Exam Preparation?
Q9: Are you using the Applications to Prepare the Exam?

The results summary is indicated in Figure 4 and the features are required in an exam paper generator and most the answers were:

- Friendly user interface.
- Specify the difficulty level.
- Time saving
- Automatic correction of the exam papers.

As shown in Figure 5 the user was already a member of the system, users' information is passed to the validation process that use data stored in a knowledge base to authenticate the identity of the user. In the case of authentication is valid the user can start using the system services, else the

Figure 4. Results Summary

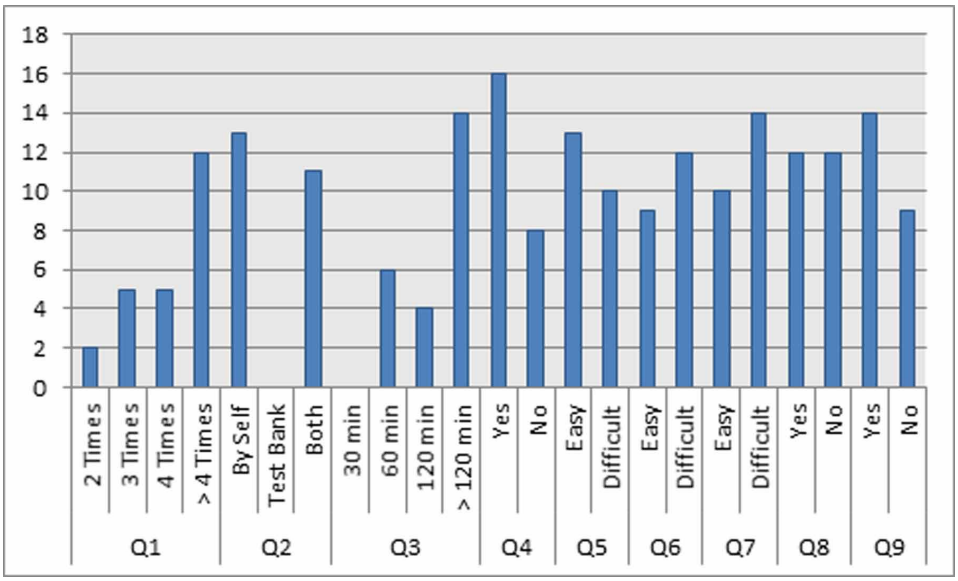
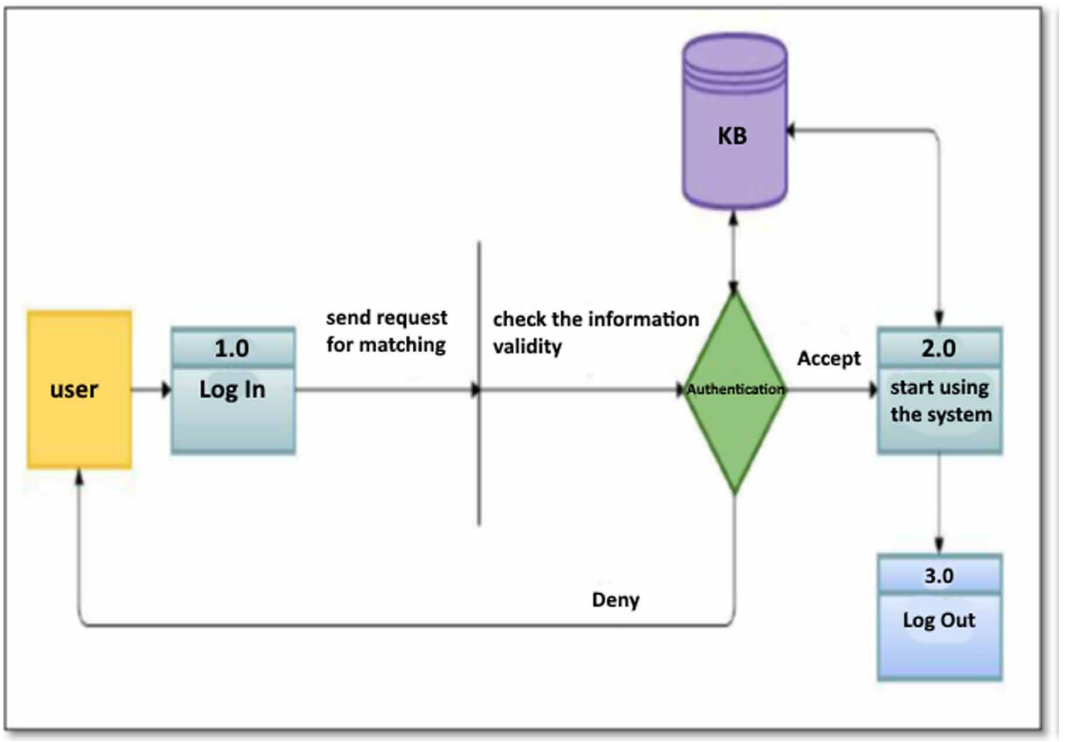


Figure 5. DFD diagram of the proposed system



access is denied. Figure 6 shows an Entity-Relationship (ER) diagram that describes a structure of a knowledge base, which data will be stored in it and how the tables could be connected. And Figure 7 indicates use case diagram of the proposed system. Figure 8 shows the system architecture of the system and the key User Interface screen indicated in Figure 9. In this work, the knowledge base is used to store user information and the exam question by the course coordinator. There are tables in the knowledge base for colleges, departments, question type, questions, and editing or deleting them.

6. RESULTS AND DISCUSSION

This system is being tested for the College of Computer Information and Sciences (CCIS) in Princess Nourah bint Abdulrahman University. Shuffling algorithm prevents duplication and repetition. As a result, to conduct several different types of the testing include unit testing, system testing and acceptance testing, the Test Paper Generation team achieved an error-free system that satisfies the functional requirements, able to retrieve data in an efficient way across real website that provides friendly user interfaces and allow multiple users using the system simultaneously. The proposed system has the following features:

1. Ease of use.
2. User-friendly interface.
3. Attractive design.
4. Correct information and coherent data.

Figure 6. ER diagram of the proposed system

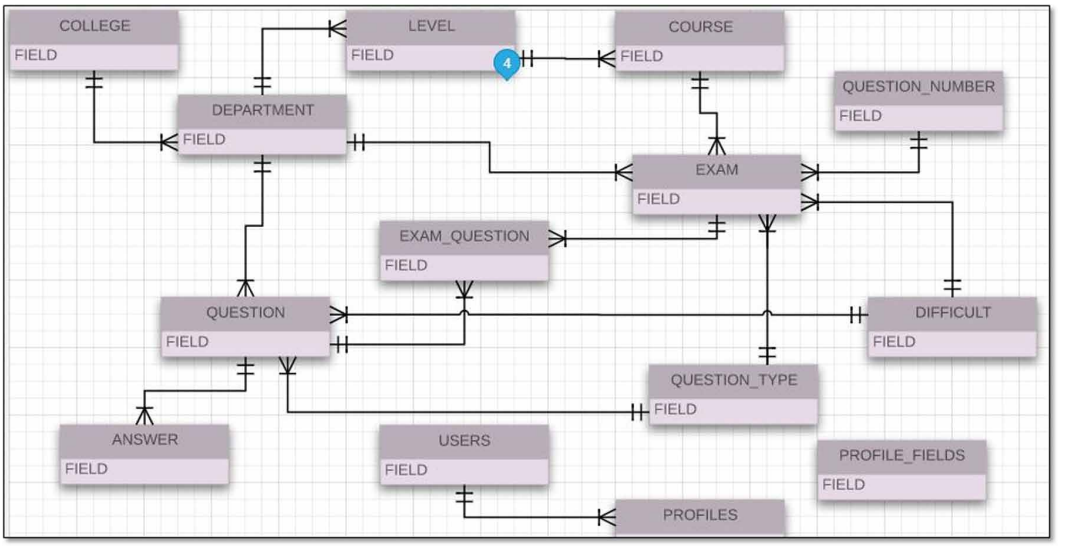


Figure 7. Use case diagram of the proposed system

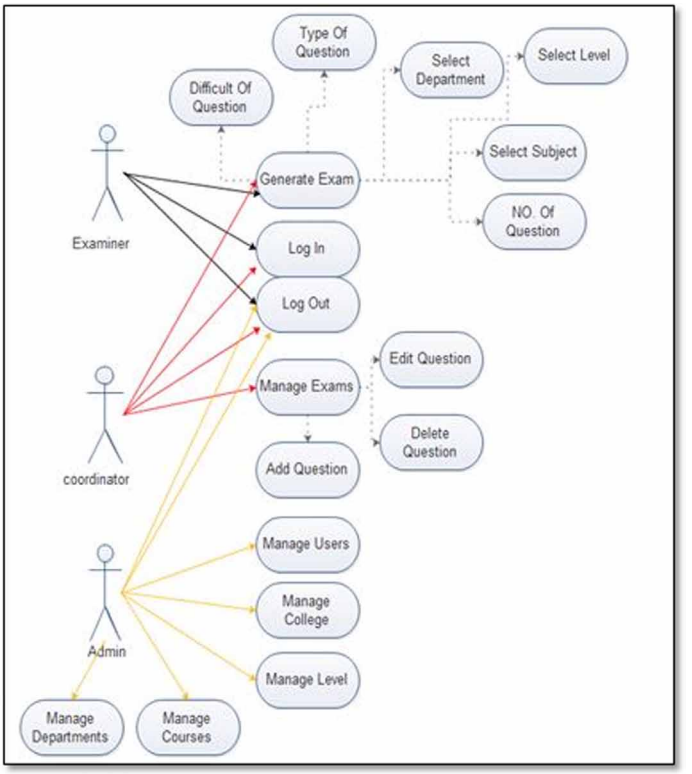
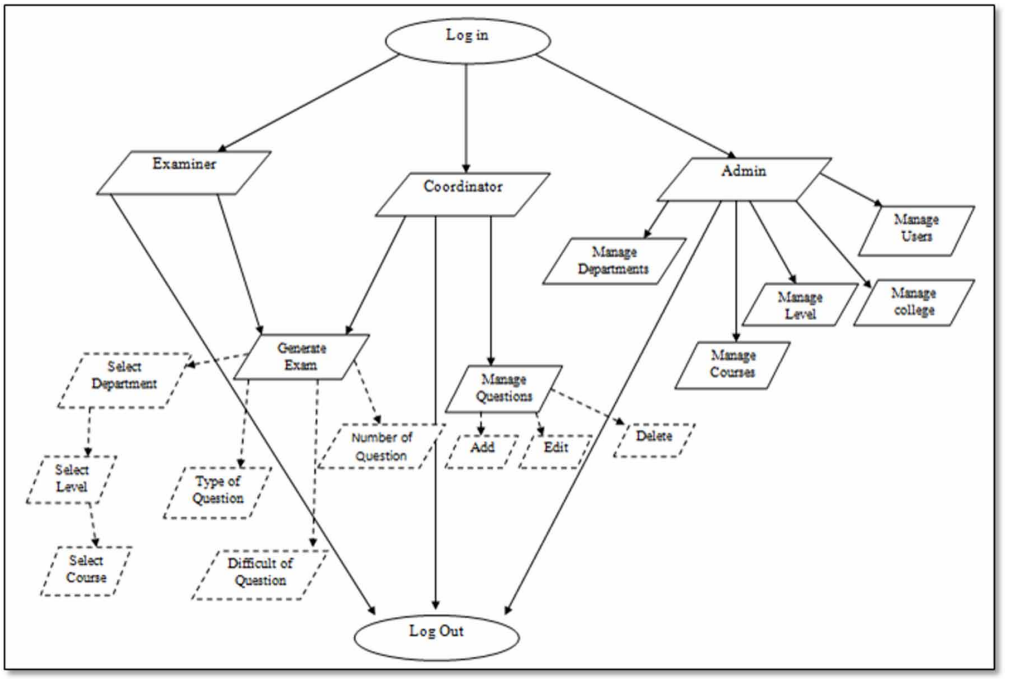


Figure 8. The proposed system Architecture

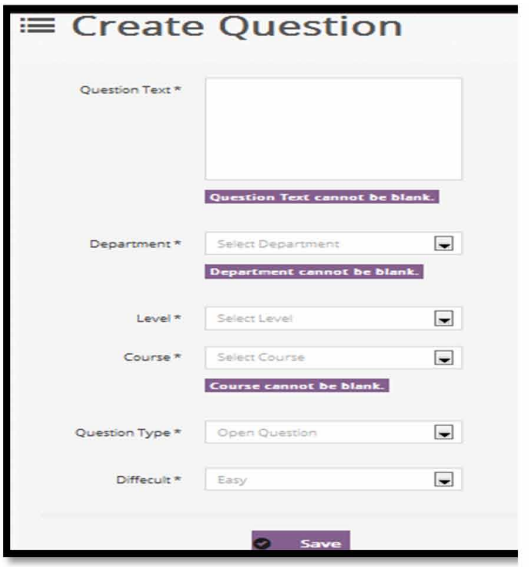


5. Administrator agent can
   - Logging (Login and Logout) anytime/ anywhere.
   - Manage users (Add, Delete, and Modify).
   - Manage colleges (Add, Delete, and Modify).
   - Manage departments (Add, Delete, and Modify).
   - Manage Levels (Add, Delete, and Modify).
   - Manage courses (Add, Delete, and Modify).
6. Faculty agent can save the work permanently, in addition to the following features.
   - Manage Exams (Create, Delete, and View).
   - Manage Questions (Add, Delete, and Modify).
   - Manage Difficulty (Add, Delete, and Modify).
   - Manage Question Numbers (Add, Delete, and Modify).
   - Manage Question Types (Add, Delete, and Modify).
   - Manage Answers (Add, Delete, and Modify).
   - Create Exam.
7. Security features
   - Ensure the Email is sent to the excepted receiver:
     - This feature should strictly be managed to ensure privacy and reliability.
   - Authentication:
     - Without Authentication, confidentiality and integrity are not guaranteed.

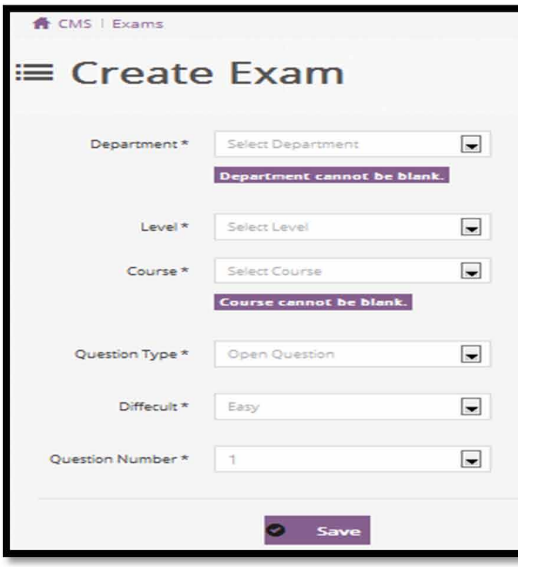
6.1. Proposed and Similar Systems Comparison

The comparison between the proposed and similar systems is indicated in Table 1.

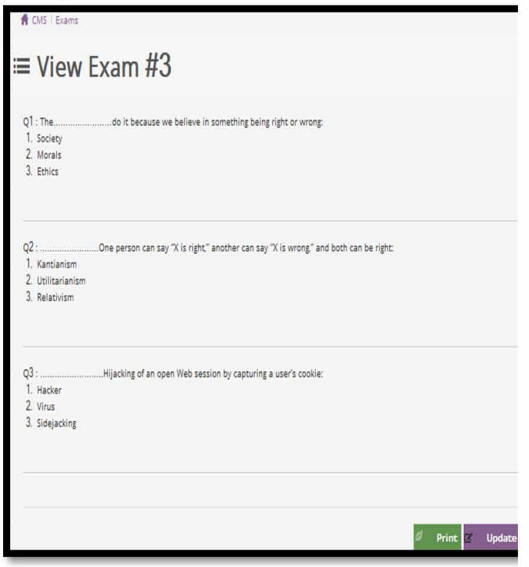
Figure 9. Key User Interface Design



Create Question Test Case



Create Exam Test Case



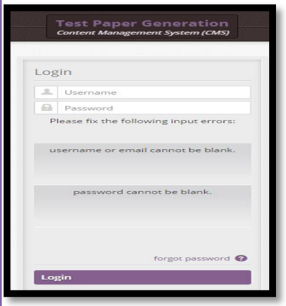
View Exam Test Case.

Manage Exam Test Case

7. CONCLUSION

Learning is an important aspect of individual's life. The base of learning is the instructors. Once the instructors have ways and tools that help them to do their task in a good way, the result is strongly scientifically generated. This work is a system which establishes question exam paper, according to what the instructor chooses to start with from identifying the college, the department, the level and the subject. After that, he chooses the kind of questions and the degree of difficulty without questions duplication. Also, he can edit some questions, and then print the paper. This web-based system aims to save time and efforts of instructors, write the questions take a long time and efforts. The proposed

Table 1. The comparison between the proposed and similar systems

	Proposed System	QGeine (QGeine, n.d.)	Qiyas (Qiyas, n.d.)
Features	It is a test paper generation system that is linked to questions knowledge base. The examiners will log into the system, specify the question type and the difficulty level and other required attributes, and then the system will automatically assemble the exam paper which will save the time and effort of the examiner and enhance standards and unified the level of difficulty between different sections.	It is a web-enabled question paper generator solution for Teachers, Tutors, Students and their Parents/Guardians, Schools and Coaching Institutes across classes and subjects. The software allows generating a question paper based on parameters like learning objectives, types of questions, competency level and difficulty level.	It is a system used unified tests to evaluate the students' learning progress who completed their learning in the university. It consists of two parts: verbal and quantitative. The main goal is the preparation of scientific standards that can be used to check and test the student in various fields.
Domain & Users	Instructors/Coordinators	ALL	ALL
Program Language	English	English	English + Arabic
Question Type	ALL	ALL	Multiple choice
Specify difficulty level	Yes	NO	NO
Interface			

system is an online system for test paper generation. It will help the user in saving his time and effort by automating the process. It will help faculty produces quality exams, according to learning outcome objective for each course. It will be modified for most educational institutes, and test paper generation website will be having an Arabic language interface in the future.

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