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## The Development of QMMS: A Case Study for Reliable Online Quiz Maker and Management System

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### Cover Page Footnote

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## **The Development Of QMMS: A Case Study for Reliable Online Quiz Maker and Management System**

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### **ABSTRACT**

The e-learning and assessment systems became a dominant technology nowadays and distribute across the globe. With severe consequences of COVID19-like crises, the key importance of such technology appeared in which courses, quizzes and questionnaires have to be conducted remotely. Moreover, the use of Learning Management Systems (LMSs), such as blackboard, eCollege, and Moodle, has been sanctioned in all respects of education. This paper presents an open-source interactive Quiz Maker and Management System (QMMS) that suits the research, education (under-grad, grad, or post-grad), and industrial organizations to perform distant quizzes, training and questionnaires with an integration facility with other LMS tools such as Moodle. The proposed system supports three basic levels: 1) administration, 2) instructors, and 3) learners at the micro-level teaching. The proposed system is adopted using .Net framework integrated with SQL-Server database engine that compromise between performance, security and stability. The proposed QMMS is described through different phases of Software Development Life Cycle (SDLC) including detailed analysis, design, implementation, testing, verification, and maintenance in order to exploit the importance of the analysis and design of LMS from the software engineering point of view. A comparative analysis, among the proposed system and a recent list of challenging ones, is presented in different aspects that shows the effectiveness, reliability and validity of proposed tool. Moreover, the proposed QMMS shows an enhancement ratio of up to 42.19% in response time perspective as compared to Moodle system in the case of massive concurrent transactions.

### **KEYWORDS**

E-learning, MCQ maker, LMS, SDLC, Relational Data Model

## I. INTRODUCTION

The e-learning field can be considered the corner stone of recent innovations in research market. In this regard, Learning Management System (LMS) becomes inevitable as it facilitates the communication among research community members in virtual spaces and at the same time, it copes with the rapid development of information technology and motivates people to learn. However, there are still gaps in research as the literature indicates, especially from the LMS management viewpoint. Over the last years, various LMS platforms are developed with different functionalities and features. The modern LMS systems can be categorized as either cloud-based that do not require a system administrator or those systems where the in-depth knowledge of web programming such as PHP, knowledge of databases management and administration, such as MySQL, Microsoft SQL Server, is necessary [1].

Continuous evaluation and assessment of trainers and employees becomes crucial for academic as well as non-academic organizations for optimal job distribution that in turn the financial markets and economies. This reflects the necessity of existing of a quiz maker system, especially for higher educational and research institutes which indeed improves the outcomes of the teaching process as compared with that of traditional classrooms. On the other side, commercial quiz maker systems have their limitations from the functional and capabilities viewpoints. Moreover, they are not upgradable free of charge. Thus, the availability of a fully customizable and open-source quiz evaluation system becomes of utmost interest. This customized system will surely fulfil all the requirements of its hosting organization with a facility to adaptively meet the traditional as well as advanced needs to reflect changes in both the

teaching process and the management hierarchy of the organization.

Over the past year, governments of various if not all countries closed their educational campuses, research centers and industrial organizations either fully or partially in order to control the wide spread of COVID-19 pandemic [2]. Accordingly, most of the world's ordinary, secondary and higher education student population is affected that massively disrupted such governments' plans [3]. As per UNESCO survey, not less than 91% of enrolled learners from about 188 countries worldwide [4], have closed their educational institutes trying to confront the spread of COVID-19. Because of COVID-19 spread, various challenges associated with the shift to distance learning have exacerbated such as the increased possibility in dishonest behaviors, the difficulty in assessing practical and metacognitive skills, the need to assure a fair evaluation and the risk of technical failure. Meanwhile, the above-mentioned challenges accelerate the demand as well as adoption of web-based technologies for the assessment and evaluation of trainers and employees. One should admit that price and personal preference are the keys when people choose most LMS systems. In most cases, they choose those with good reviews and regardless of its qualities and capabilities, users would hardly replace it with a different LMS framework.

The main contribution of this paper is related towards a reliable distant learning, monitoring and management of a Quiz Maker and Management System (QMMS). This paper revealed the lack of clear analysis and design of Web-based quiz makers from the software engineering viewpoint. It was noticed that different technological platforms are treated in a generic way and that there is few empirical research focused on the topic. The stability testing of the proposed system with tenth of thousands of concurrent transactions shows the ability to

deliver the service as well as dynamically load balance the resources to meet users' demands with high effectiveness and responsiveness. Numerous experts in their fields evaluated the system and the comments have been documented as a reference for the improvement and reflective development. From security viewpoint, the proposed system meets the essential security requirements, which have a strong influence in the collaborative learning process. It shows the ability to protect information while delivering the service while offering the key security properties such as

availability, identification and authentication, access control, integrity, confidentiality, time stamping and failure control. Finally, the proposed system provides a user-friendly interface to facilitate the interactive learning with the ability to integrate with different LMS tools.

The rest of this paper is organized in five main sections. Section 2 lists recent LMS systems as competing ones for the proposed QMMS. In Section 3, the development life cycle of the proposed QMMS, including its different phases, is described in detail.

Section 4 explores the proposed system validity and stability including a comparative analysis against competitive LMS tools. Conclusion and suggested future work are presented in Section 5.

## II. RELATED WORK

In most studied articles, scientists have proposed evaluation models for LMS platforms, however they have analyzed with them only limited features [5]. When MCQ-based exam is delivered online, students may become anxious due to the time-constrained assessment as well as the unfamiliarity of using the advanced technology. Moreover, not less than 10% of students have admitted to cheating under test-room restrictions [6]. Moreover, the review and analysis studies showed that 68% and 43% of both undergraduate as well as graduate students, respectively have committed cheating in e-tests [7].

Recently, numerous features are provided by different LMS tools, e.g., Moodle [8, 9], Edmodo [10], Coggno [11], Paradiso [12], eCollege [13], Blackboard INC [14], Schoology [15], Sakai [16], Atutor [17], FormaLMS [18], ClassMarker [19], Go Conqr [20], iSpring Quizmaker [21] and Poll Maker [22]. Each LMS of these competing approaches supports specific features but not all the required features. Each one may suffer from a missing feature or a weakness in some of its supported features. In this paper, a comparative analysis is presented between these competing LMS systems and the proposed QMMS based on different perspectives.

The proposed Quiz Maker and Management system (QMMS) is directed towards educational organizations to support the teaching as well as holding scientific competitions and selections. In addition, the proposed system suits the non-academic organizations as well. The term quizzes will be used for description in following subsections in the paper, as they are similar to the MCQ questionnaires, however with no auto-marking and scoring.

## III. QMMS DEVELOPMENT LIFE CYCLE

The general Software Development Life Cycle (SDLC) represents different phases; 1) requirement analysis and customization phase, 2) design phase, 3) implementation phase, 4) testing and validation phase, and finally 5) deployment and maintenance phase. A targeted software system should go through these phase to ensure that all its technical and management activities are accurately performed.

A preliminary problem solving phase and feasibility study, that itself incorporates the analysis and gathering of the relevant information to the product is adopted prior to requirement analysis phase. The proposed system is hosted on a client-server based network that interconnects all educational entities and provides the required services to students through the educational plan. The proposed QMMS system is a web-based, that

is developed as web forms hosted by a web-server that interacts with a database (DB) engine on a database server for the information delivery and retrieval. Hence, the critical advantages of the proposed system are its potential for reducing costs as well as the ease of installation, maintenance and upgrading on various platforms [23, 24]. Moreover, the proposed system facilitates the process of user enrolment, grade export and quiz import through various templates on different operating systems. Compared with other systems such as Moodle [8, 9] and Edmodo [10], the proposed system automatically provides a way to detect the illegal browsing during the e-assessment.

#### A. QMMS Analysis Phase

The preliminary analysis and customization phase is important to fulfil the exact needs of the customer. It is of utmost importance, upon which the all the succeeding phases rely. For such phase, several meetings at different levels with the manager of the educational organization, network administrator, staff of the educational affairs and several discussions and questionnaires are held, in order to maximize the outcome of the educational process according to the requirements, needs, and hopes.

A Technically perspective, the main purpose is to develop an open-source software application system that facilitates the following requirements for the instructors:

- Provide a secure environment for e-assessment through robust and safe exam browser that impedes fraud during online examinations,
- Easily construct questions banks for different educational courses with the ability to import as well as export questions in various formats,
- Create multiple choices quiz-based exam(s) with numerous multimedia features for both training and/or real exams, and

- Configurations Real-time monitoring and analysis of the results during online examination.

From student's perspective, the proposed system facilitates:

- Take the assigned exams according to scheduler time line and monitor their marking with a feedback review to maximize the learning outcomes and
- Track the progress in educational process with the ability to create test exams from a special question banks to prepare for the real ones.

The proposed QMMS system compromises both instructor and learner main modules, in addition to an administrative module that monitors the overall outcome of the learning process. The functional as well as context requirements, which describe features and available services, are itemized below:

For administrative module:

- Controls the educational system scheduling including semester, time table and full management of scheduled tasks including but not limited to system backup, restore and upgrade.
- Define and assign different roles, permissions and access rights for different accounts including teachers and students.
- Enrolments of students with the ability for bulk enrolment into system DB.
- Provides tools for stability and load testing of the whole system through artificially simulated transactions and traffic.
- Real-time monitoring of the system
- performance against concurrent access to the system resources.
- Full monitoring and tracking of all student activities through system-wide reporting statistics, error and live logs.

- Course creation with the ability course clone, backup and restore.

For instructor's module:

- Course management with the ability to upload multimedia contents.
- Proctoring feature, in which the exam is inaccessible till the time of publishing.
- Create question banks with the ability to categorize the questions into levels according to difficulty.
- The ability to create question pool through which students can create sample quizzes for training.
- Facilitate the shuffling option among questions and their corresponding answers to improve the system efficiency as well as controlling the access restrictions.
- Grouping students to facilitate assigning different tasks to separate groups to maximize the effectiveness of the learning system.
- Facilitates the organization of the exam and the way students take a feedback according to their answers.
- Full monitoring, analysing and reporting of student activities with automatic as well as manual marking and scoring of exam questions.

For learner's module:

- Displaying the assigned activities on the student timeline and facilitates the activity submission according to pre-scheduled time constraints.
- Displaying questions and corresponding choices of the exam shuffled as a proactive approach that might reduce the inclination to cheat.
- Provide students the ability to create training quizzes from question pools assigned to the corresponding courses to improve the efficiency of the learning outcomes.

- Monitoring and tracking of student progress and marking/grading through the semester.
- Provide students with the ability of self-enrolment into promoted courses to improve their skills.

### B. QMMS Design Phase

The use case diagram illustrated in Fig. 1 represents how different agents, entities or simply actors interact with the system application in different cases [23, 24].

In general, this incorporates the goals, the functional as well as context requirements of the system in addition to the basic flow of events. The use case diagram for the proposed system is illustrated in Fig. 1 as shown below including the three main entities of the system namely administrator, teacher and the student.

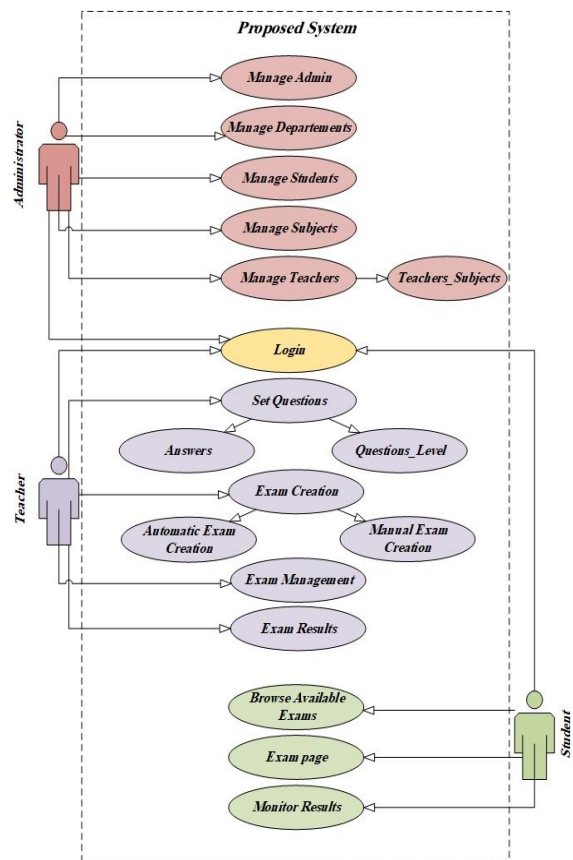


Fig. 1 Use case scenario of the proposed QMMS.

Special charting models and visual paradigms such as data flow diagrams (DFD) help the analyst exploit requirement determinations. DFD is a structured analysis and design tool that allows the analyst to visually comprehend the system and its corresponding subsystems as a set of interrelated data flows. It usually charts the

input, processes, and output functions of the business model. Fig. 2 illustrates the context diagram of the data flows to and from the system including the external entities. Diagram 0, which is the next level, shows processes as well as data stores at this level as shown in Fig. 3.

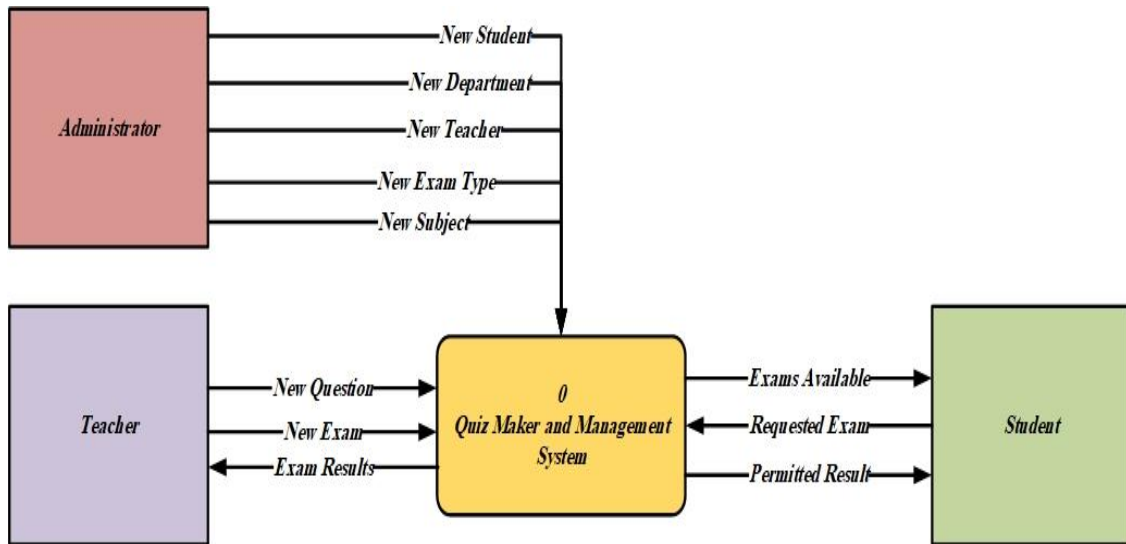


Fig. 2 DFD - Context diagram of the proposed QMMS.

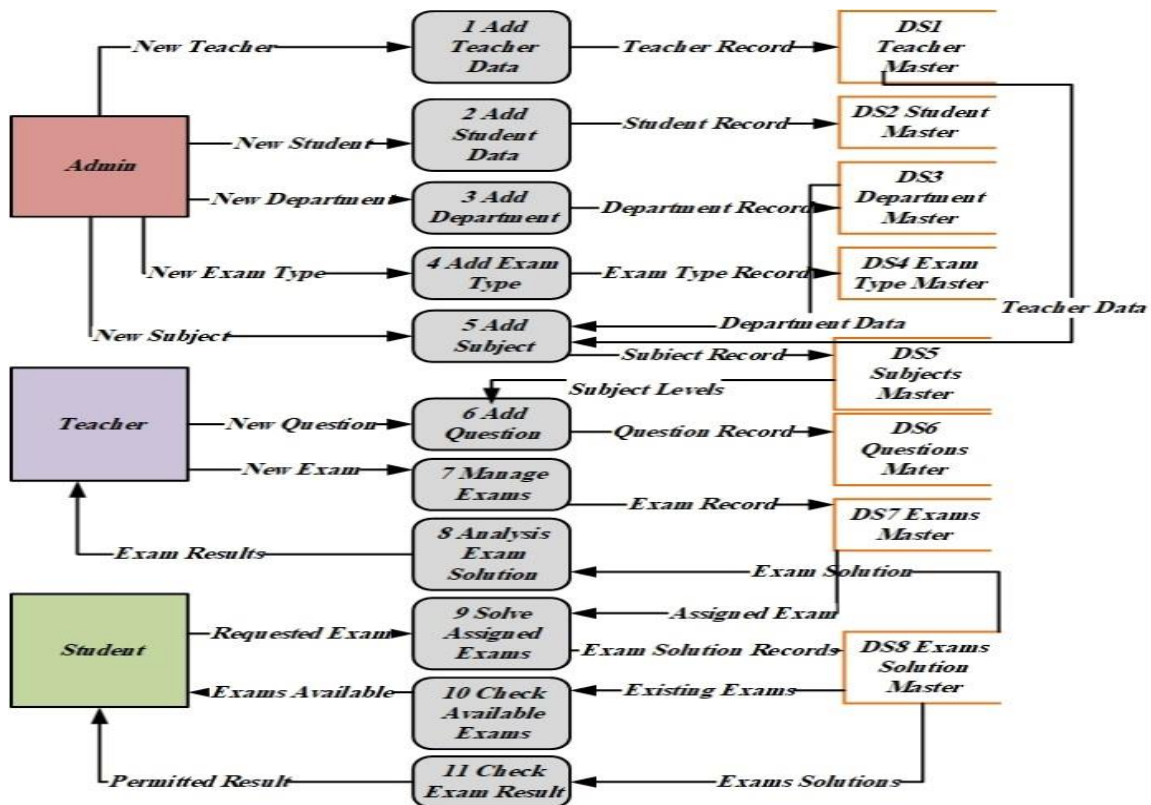


Fig. 3 Diagram 0 of the QMMS Data Flow Diagram.



|                           |  |  |  |
|---------------------------|--|--|--|
| Year Record               | = Year ID +<br>Year Name   | Department Record                                      | = Department ID +<br>Department Name   |
| Degree Record             | = Degree ID +<br>Degree Name   | Term Record  | = Term ID +<br>Term Name   |
| Admin Record              | = Admin ID +<br>Admin Name +<br>Admin Password   | Teacher Record   | = Teacher ID +<br>Teacher Name +<br>Teacher Phone +<br>Teacher Email +<br>Teacher Password +<br>Degree ID +<br>Department ID             |
| Student Record            | = Student ID +<br>Student Name +<br>Student Phone +<br>Student Email +<br>Student Password +<br>Department ID  | Subject Record   | = Subject Code +<br>Subject Name +<br>Subject Hours +<br>Department ID +<br>{Teacher ID} +<br>{Subject Levels} +<br>Year ID +<br>Term ID |
| Question Record           | = Question ID +<br>Teacher ID +<br>Question Text +<br>Question description +<br>{Question Answer Record} +<br>Subject ID +<br>Subject Level ID   | Question Answer Record                                 | = Answer ID +<br>Teacher ID +<br>Answer Text +<br>description [True   False] +<br>Question ID  |
| Exam Type                 | = Exam ID +<br>Exam Type Name  | History Solution Of Student Of Question In Exam Record | = Exam ID +<br>Student ID +<br>Question ID +<br>Answer ID  |
| Student Group             | = Group ID +<br>Group Name +<br>{Student ID}   |  |  |
| Exam Student Group Record | = Exam ID +<br>Group ID +<br>Exam Date   |  |  |
| Exam Record               | = Exam ID +<br>Teacher ID +<br>Exam Date +<br>Subject ID +<br>Exam Type ID +<br>Monitor_Result_Autherization [Yes   No] +<br>Num_Questions +<br>{Exam Questions Records} +<br>Correct Weight Factor +<br>Incorrect Weight Factor +<br>Unsolved Weight Factor |  |  |

Fig. 4 QMMS Data Dictionary Model.

The proposed system went through the data flow details that is considered an important among other processes, which need deep analysis and description. In such system, the teacher manages exams starting from exam creation, question banks, time constraints, grouping students and monitoring the exam activities. Students interact with their assigned exams including navigation among exam questions, tracking the status until the submission with a complete feedback after the exam to improve the efficiency the learning system. In general, the data structure describes the data flow details through a Data dictionary entries created for each DFD, as shown in Fig. 4. Algebraic notation are commonly used to describe Data structures, and usually uses "=" that means, "is composed of.", "+" that means "and.", Braces "{ }" to indicate repetitive

elements, Brackets "[ ]" to represent an either-or situation, and finally Parentheses "( )" that represents an optional element that either left blank or may contain spaces or zeros for numeric fields in file structures.

The use case can be considered as a set of scenarios, which are reported using sequence diagrams, in which objects are represented as vertical lines and messages among such objects are represented as directed horizontal lines [23, 24]. A sequence diagram simply depicts the interaction among entities in a sequential order that is the order in which these interactions take place. The sequence diagrams of administrators and students are shown in Fig. 5 and Fig. 6, respectively, while the sequence diagram of the teacher is partitioned into Fig. 7 and Fig. 8.

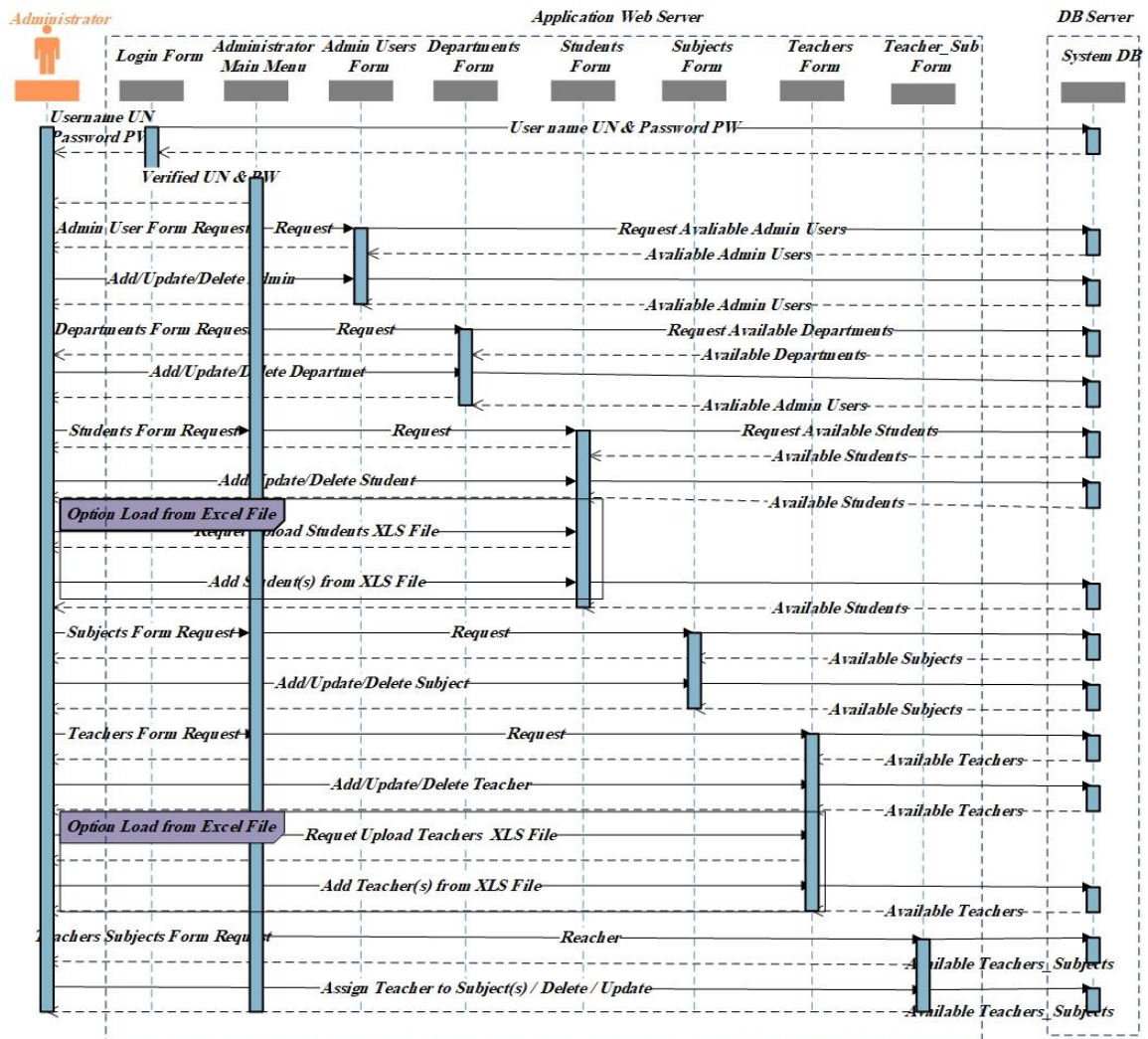


Fig. 5 QMMS sequence diagram of administrators.

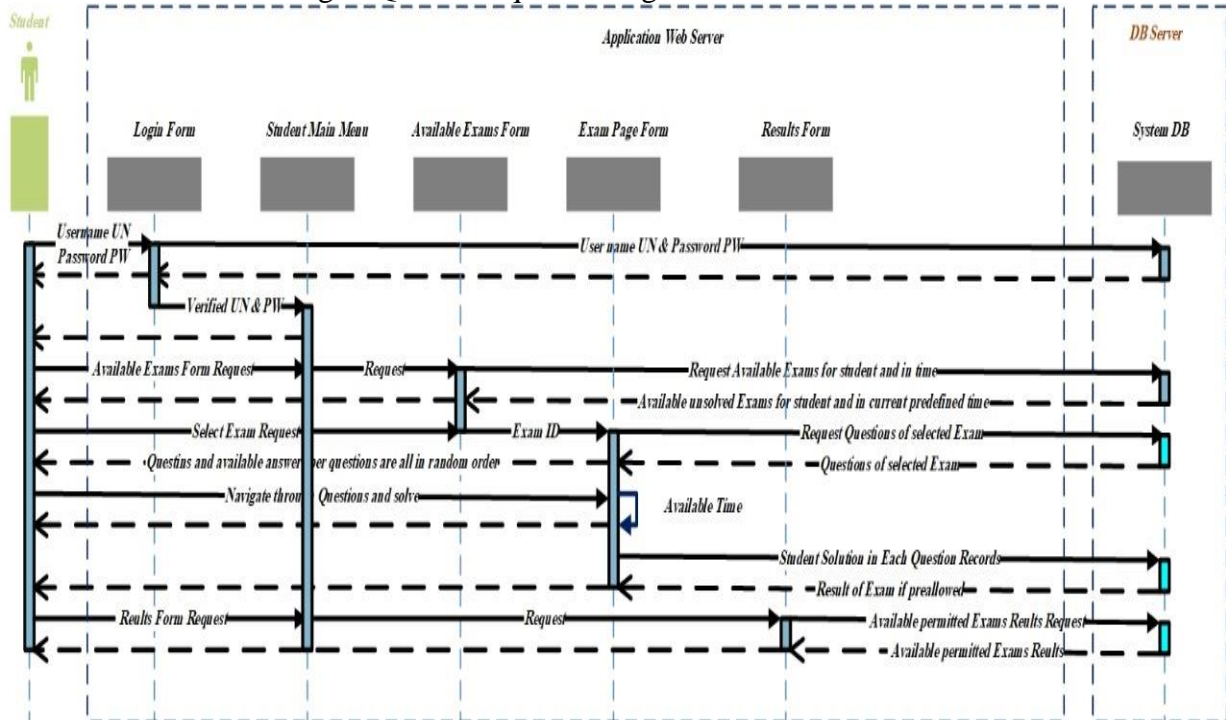


Fig. 6 QMMS sequence diagram of students.

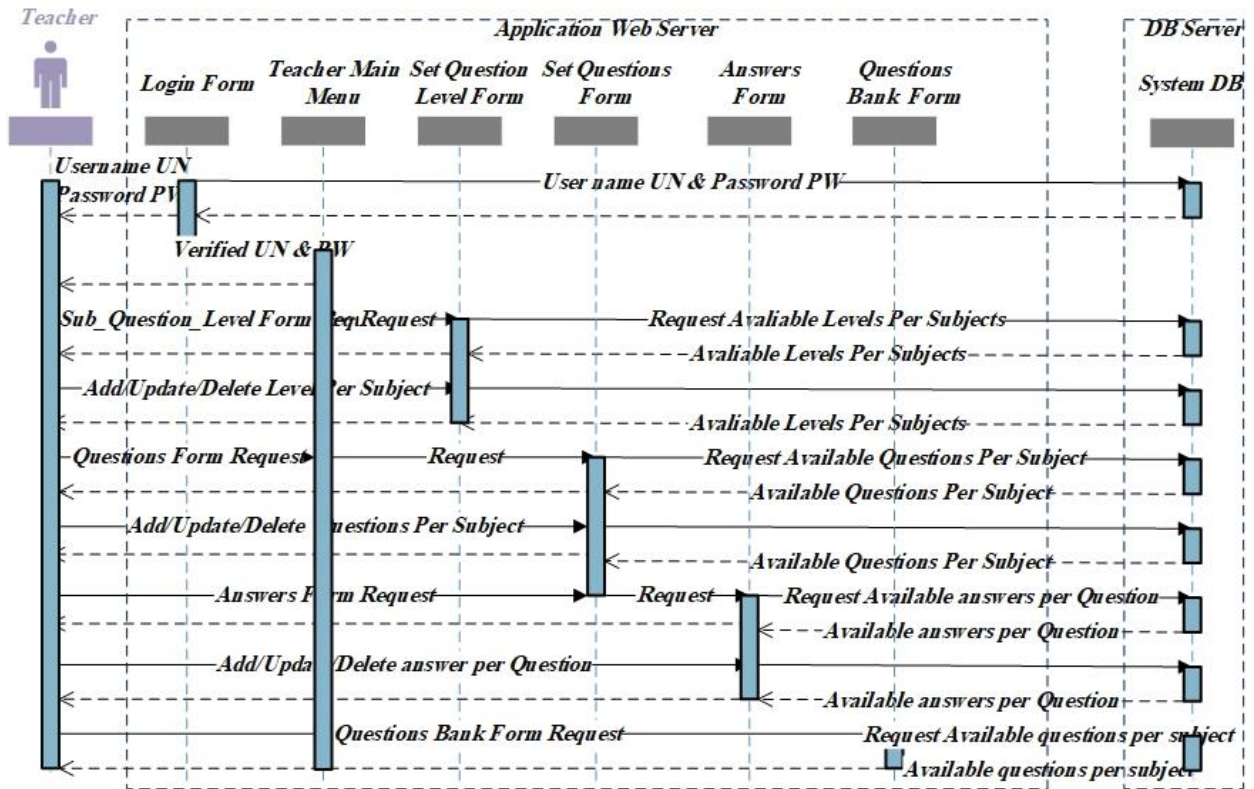


Fig. 7. QMMS sequence diagram (part1) of teachers.

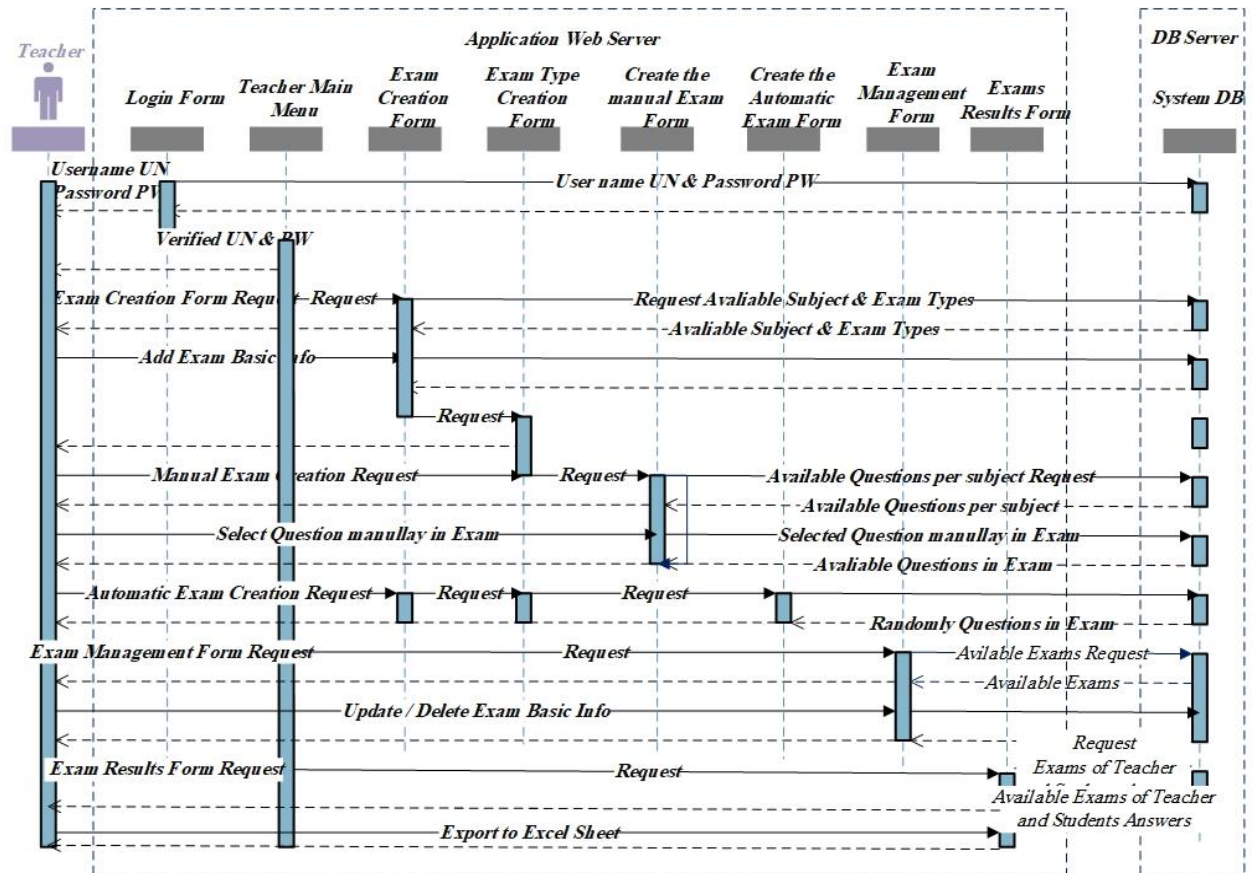


Fig. 8 QMMS sequence diagram (part2) of teachers.

The design phase exploits the Relational Data Model (RDM) of the proposed QMMS that provides a declarative way to specify the data as well as queries. The advantage of the RDM over other models is multifold [25]: data integrity is provided at the relation, field and database level; independence of the data logically and physically, data consistency and accuracy guarantee; and reliability in data retrieval through queries. Such design elements accurately describe the major entities within the system scope as well as the inter-relationships among these entities, in a way skilled developers easily refine and publish the system with minimal additional input design. The proposed system RDM is illustrated in Fig. 9. The goal of the design phase is to transform the requirement specification into a structure that facilitates the development and implementation.

An important part of the logical design of the information system is adopting the human-computer interaction in an interactive environment [8, 9]. The interface interactively

attaches the end user with the system application and is thus significantly important. In the proposed QMMS system, the user interface is designed in a way to ensure that the system is audible, legible and attractive. User interfaces adopt a keyboard (to put down questions and answers), on-screen menus (to prompt user commands) and a miscellaneous Graphical User Interface (GUI) forms. The main forms of the proposed QMMS system are snapped and presented in testing and verification phase.

*C. QMMS Implementation Phase*

The proposed system incorporates an application as well as database model. The QMMS application model is adopted as web-server using ASP.NET framework while the database model is developed using SQL-server. The Microsoft FrontPage is adopted to improve the system interactivity. The QMMS supervises the user permissions and policies, facilitates courses, quizzes and questionnaires management and submission as well as advanced real time monitoring. Figures 10-14 illustrate the login, administration, teacher, student and exam web forms of the proposed QMMS system, respectively.

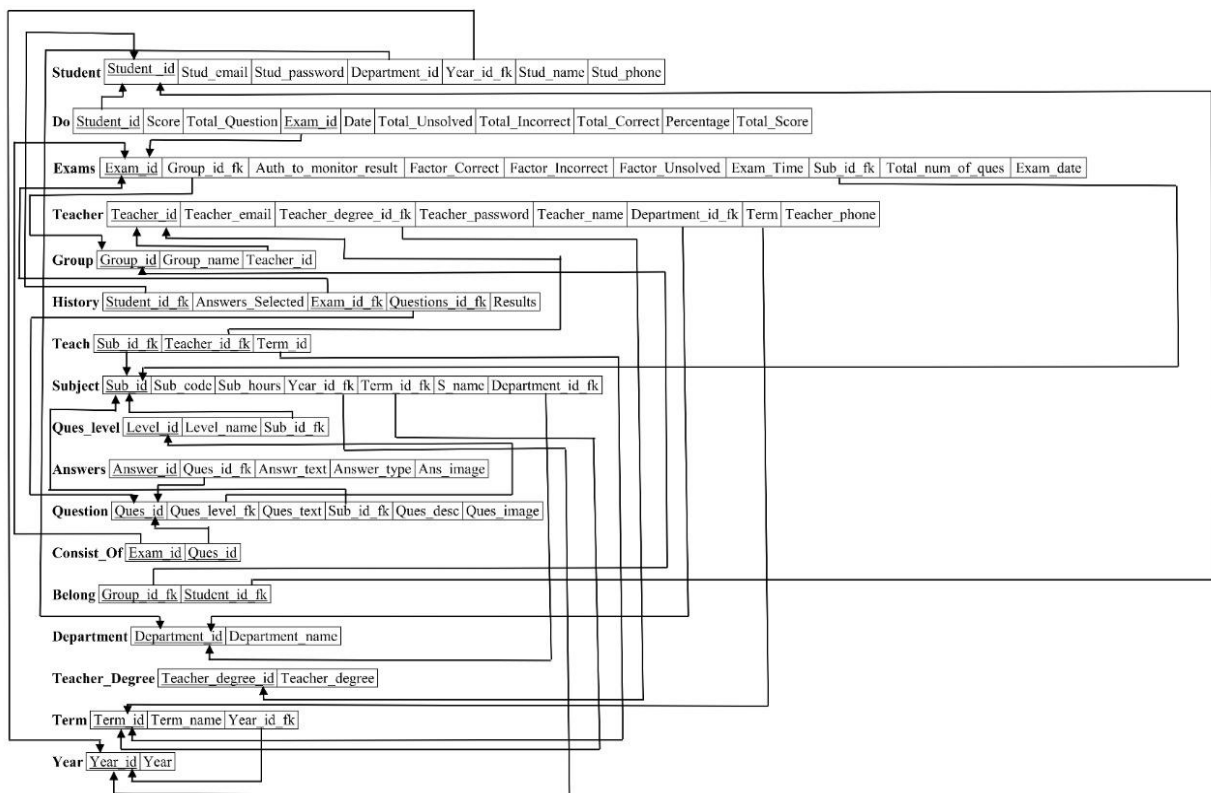


Fig. 9 RDM of the proposed QMMS.

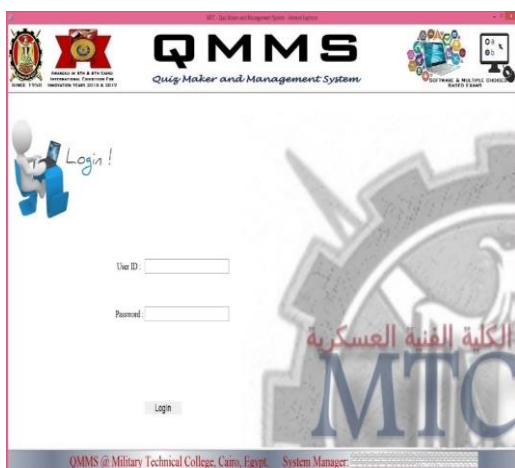


Fig. 10 Login web Page.



Fig. 11 Teacher's master web page.



Fig. 12 Administrator's master web page.

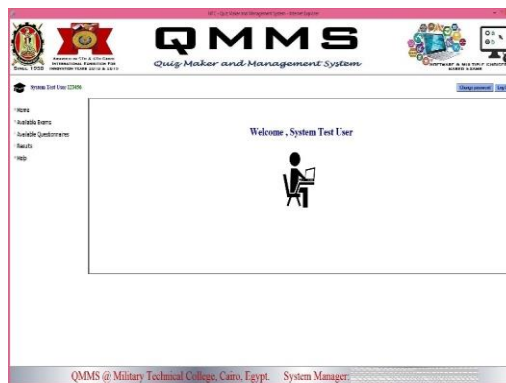


Fig. 13 Student's master web page

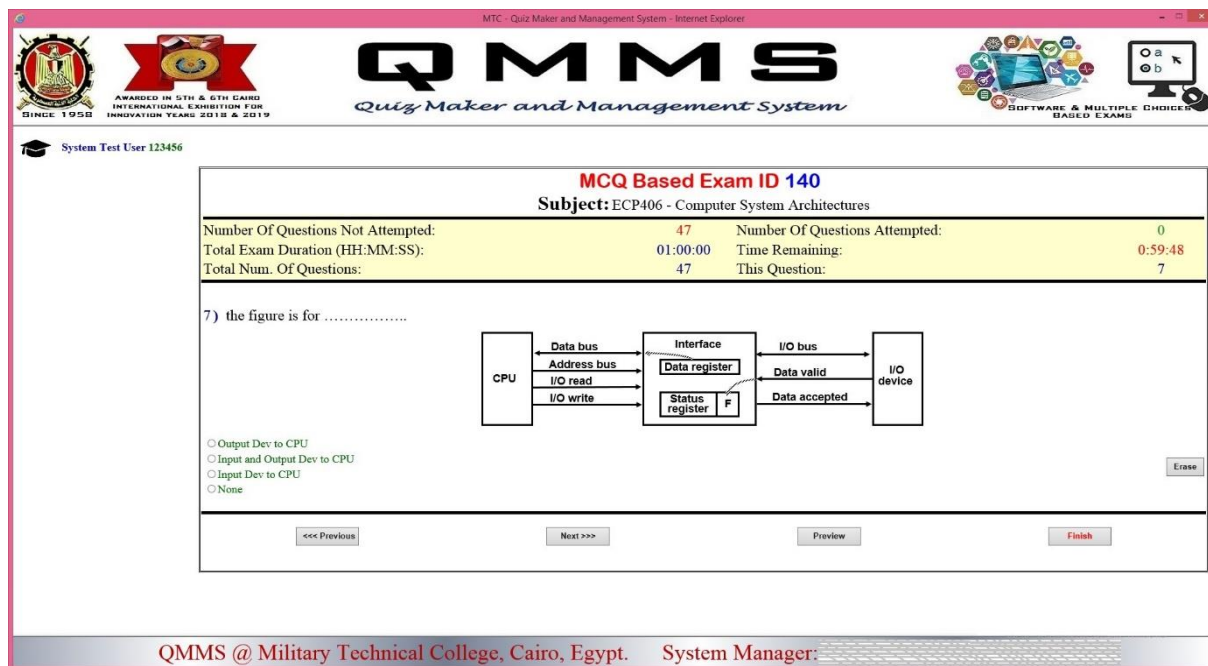
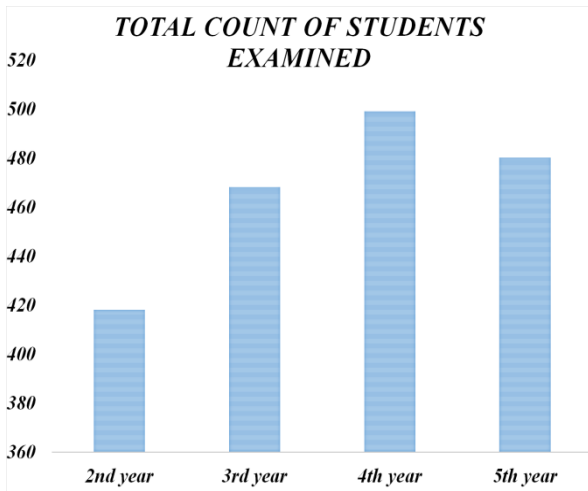


Fig. 14 Student's exam web page.

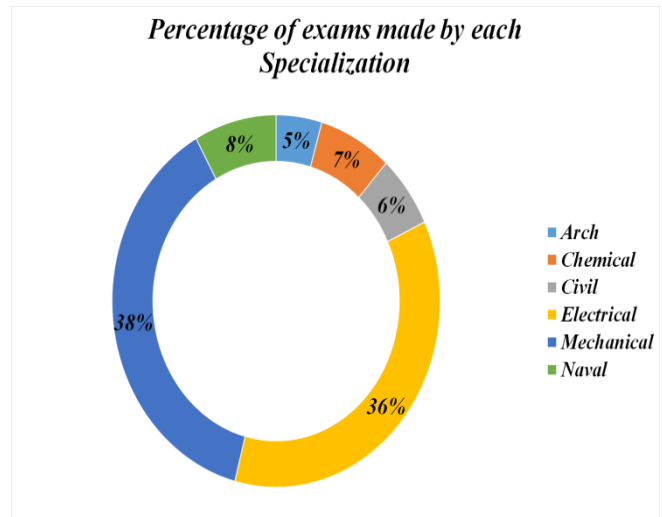
*D. QMMS Reporting and Monitoring*

The QMMS facilitates various types of administration reporting and analysis that can be either run on demand, or scheduled to run automatically. To mention a few, they inform the administrator how the quizzes are being used by users; provides the administrator a

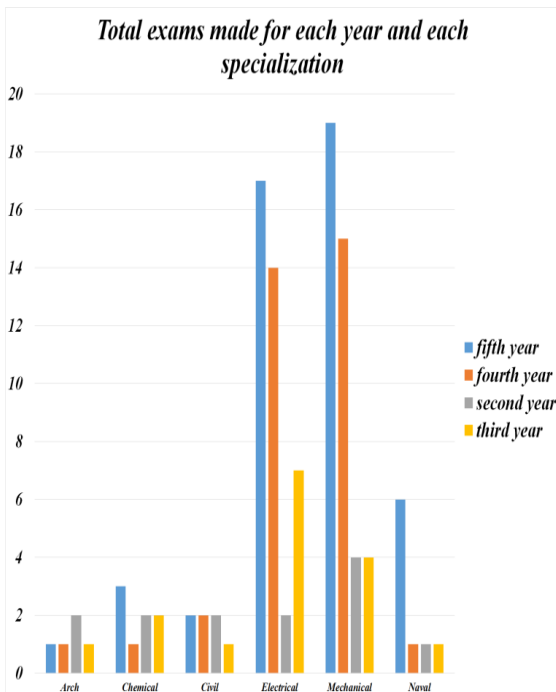
quick overview of the users access to courses and quizzes; the total quizzes made by user in a period of time; percentage of quizzes made among different groups; an overview of the most accessible resources and finally shows the online users and daily usage that most affects the system performance. Fig. 15 a)-d) shows few of the reporting facilities of the proposed QMMS.



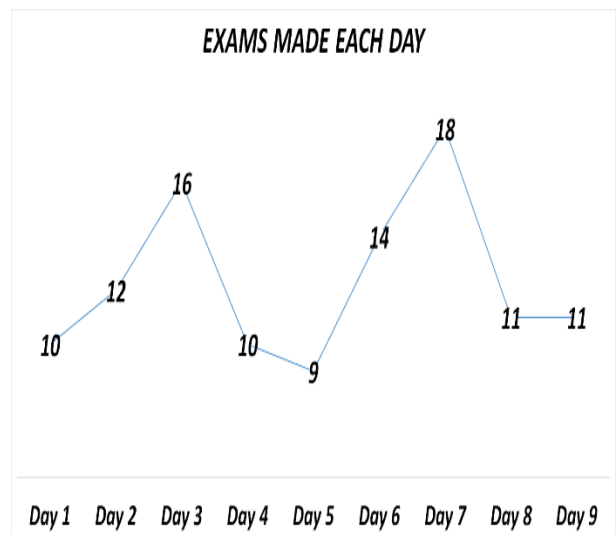
a)



b)



c)



d)

Fig. 15 QMMS reporting facilities.

#### IV. QMMS VALIDATION AND MOODLE-INTEGRATION

##### A. QMMS Stability Testing

Massive amounts of concurrent transactions are employed to examine the proposed QMMS system stability, reliability and responsiveness on all web pages. As compared to Moodle 3.9 hosted on a Windows 64-bit OS server, the proposed system provides a reliable behaviour against concurrent requests and shows better performance as illustrated in Fig. 16. In response time perspective, the QMMS shows an outstanding performance with massive concurrent requests compared to Moodle system. The experiment is adopted on a server with Hexa-Core 2.6 GHz i7 processor, 16 GB NVIDIA, 6MB CACHE memory and 1TB SSD.

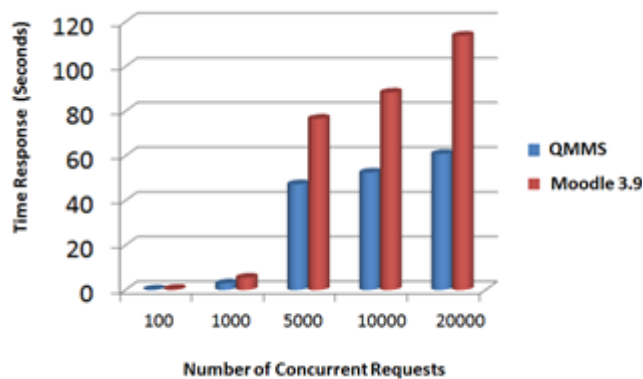


Fig. 16 Performance analysis of QMMS vs. Moodle.

##### B. QMMS Comparison against Competitive Tools

Although LMS recently facilitates various services for both educational and business organizations as well, we have to consider factors such as installation cost, license, fees per user/course and the ongoing maintenance. Recently, LMS tools provide numerous features, however: (1) they might not support server-based hosting (only cloud-based) such as Edmodo [10], Cogno [11] and Paradiso [12]; (2) they might not be cost-free (commercial) such as eCollege [13], Edmodo and Blackboard INC [14]; (3) they might not support the

advanced quizzes such as Moodle and Blackboard INC [8, 9]; (4) they might not support course customization such as Cogno and Schoology [15]; (5) they might not support mobile application such as Cogno; (6) they might not be user friendly such as Sakai [16], Atutor [17] and FormaLMS [18]; (7) they might not support grouping large number of users such as Moodle [8, 9]; (8) even famous online tools such as Respondus [26] with their eye-tracking and secure Lock-Down browser features couldn't prevent cheating during examination. To sum up, the proposed QMMS to some extent facilitates as well as provides a solution for the above mentioned weakness of the currently available LMS tools as it provides a user friendly interface, fully customizable quizzes, stability against concurrent requests, support mobile applications, open-source and cost-free and supports server-based hosting and can be easily extended to support cloud hosting.

##### C. QMMS-Moodle Integration

To the best of our knowledge, the integration among different LMS tools and publicly available Quiz makers is challenging from the viewpoints cost per user and upgrading policies as well as compatibility with the in-built plugins. The QMMS facilitates the bi-directional integration with Moodle [8, 9] LMS in the application level. It support Moodle versions 1.9 thru 3.9.X. LMSs are becoming important for training staff and students, however many LMS have limited features of their in-built quiz plug-in. This is where Quiz-Makers play an important role for both education as well as Business.

Recently, web-based Quiz-Makers become widely available such as the one provided by the ClassMarker [19], Go Conqr [20], and iSpring Quizmaker [21] and Poll Maker [22] which all provide a wide variety of features for both e-testing and e-assessment. However, firstly, one have to pay an average cost of 25-30\$ or 50-60\$ monthly without user limitation for either the educational or business organization respectively and still has a limited tests per year while iSpring Quizmaker cost about 2\$ monthly per user. Secondly, while the integration of such commercial Quiz makers with the LMS

facilitate automatic update of quiz results with users' accounts upon the test completion through webhooks, the system administrator might face a plug-in incompatibility with system upgrade. At last, most of such commercial tools come with advertisements that is slightly annoying.

From the above mentioned, the proposed QMMS provides a fully customizable Quiz maker as an online solution for both business and educational assessment. The QMMS facilitates the instant quiz grading with the ability to automatically synchronization with Moodle LMS through an API request. As a result, the QMMS overcomes the cost, compatibility and upgrading shortages of the publicly available quiz maker commercial tools.

## V. CONCLUSION AND FUTURE WORK

This paper revealed the lack of clear analysis and design of LMS tools from the software engineering viewpoint. The achieved QMMS application tool effectively joins the three major entities in the educational process: administration, teachers and learners without either users or courses limitation. Compared with other LMS tools, the QMMS interactively offers a cost-free, open-source, fully customizable Quiz maker as an online solution for both business and educational assessment. The stability as well as load testing of the proposed system shows high effectiveness and responsiveness with tens of thousands of concurrent transactions. The proposed system proactively shuffles questions and their corresponding choices that reduces the inclination to cheat facilitates the management of question banks to enrich the system pools. Moreover, non-skilled end-users can still easily interact with QMMS with both server-based as well as cloud-based hosting support. The proposed QMMS provides the ability to easily integrate with other LMS such as Moodle with detailed live logs and reporting.

As a future work, it is intended to embed the QMMS as an installed plug-in inside Moodle [8, 9] as well as other LMS tools. Moreover, it is planned to implement an embedded webhook in order to instantly synchronize the quiz results with Moodle in real time upon the test

completion despite using an API in the form of request-response scenario.

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