Problem-Based e-Learning and Evaluation System for Database Design and Programming in SQL

Abu Sayed Md. Latiful Hoque, Mohammad Mahfuzul Islam, Md. Iqbal Hossain, and Md. Faysal Ahmed

***Abstract*—Problem-based e-Learning (PBeL) can be a highly successful model for the teaching and learning of Database, one of the core courses of Computer Science and Engineering in undergraduate level. There are very few e-Learning systems found to support the learning of the different components of Database course. Existing systems provide only the partial solution of extensive learning of this course and also do not support the automatic evaluation of student performance. The main components of database practical course are: database design, SQL, PL/SQL and implementation of database projects. In this research, we have developed a system: SQL Learning and Evaluation System (SQL-LES) for effective teaching and learning of all of the above components of the practical parts of the database course.**

We have developed a question bank covering all areas of SQL questions and answers. The question bank can be used for both learning and automatic evaluation of student's performance by creating test sets and assigning the test sets to the individual students. The system can effectively be used for the teaching, learning and evaluation of database design, PL/SQL and database projects as well. SQL-LES has been applied in teaching, learning and evaluation of database laboratory course in undergraduate level of the Department of Computer Science and Engineering (CSE), Bangladesh University of Engineering and Technology (BUET) in several years and found to be very effective in classroom environment.

***Index Terms*—E-learning, problem based learning (PBL), SQL-LES, SQL learning.**

I. Introduction

Problem-based Learning (PBL) is a blended learning environment, a combination of self-directed learning and collaborative learning. In engineering education, students feel affection for the problem-based learning quiet well, and their academic achievements also better than expected [1]. Still now it has not been using widely in engineering education. E-Learning has widely been using in distance learning and web-based learning. An emerging field of research in e-Learning is the use of e-Learning in engineering education along with the problem-based learning.

Many researchers have focused on teaching strategy, student learning, tutor roles, student roles, grading, and group distribution [1]-[3]. Meaningful learning and problem solving can only be acted out in a certain learning environment [4]. Hung [5] proposed the 3C3R paper based model, a systematic conceptual framework for guiding the design of effective and reliable PBL problems. PBL activities like report submission, group discussion, construction of learning content, student feedback and assessment have supported with web-based learning environment [6], [7]. A number of research and development has been done on e-Learning to support problem based learning [8], [9].

Engineering courses are balance between theory and practice. Workflow based e-learning framework has developed to support practical environment in design engineering education [10]. Problem-based Learning (PBL) can be combined with e-Learning (PBeL) to develop a highly successful model for the teaching and learning of Database, one of the core courses of Computer Science and Engineering in undergraduate level. There are e-Learning systems found to support the learning of the different components of Database course in non-interactive mode. These systems also do not support the automatic evaluation of student performance. These systems are useful for the learning of database theory course. The main components of database practical course are: database design, SQL, PL/SQL and implementation of database projects. The practical components should be learnt in an interactive mode. In this research, we have developed a system called SQL Learning and Evaluation System (SQL-LES) for interactive teaching and learning of all of the above components of the practical parts of the database course. The existing systems support a limited amount of automatic evaluation of student performance [11]. The evaluation can be done automatically by using SQL-LES and the teachers can monitor the student's submissions in real time.

We have developed a question bank covering all areas of SQL questions and answers for single to multiple table queries and simple to complex queries. The question bank can be used for learning purpose. Teachers can create test sets using the question bank by selecting questions of different level of complexities. For any particular topic, teacher can create multiple test sets and assign the test sets to individual student in the class. The system can effectively be used for the teaching, learning and evaluation of database design, PL/SQL and database projects as well.

SQL-LES has been applied in teaching, learning and evaluation of database laboratory course in undergraduate level of the Department of Computer Science and Engineering (CSE), Bangladesh University of Engineering and Technology (BUET) in several years. It has been found that the student attentiveness and satisfaction in learning in the class has been increased by using the system. The problem-solving capabilities of the students have also been found to be increased. At the same time, the teacher's workload has been reduced significantly.

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II. System Architecture

The overall SQL-LES architecture (Fig. 1) is a combination of six interconnected modules: Data Set Management Module (DSMM), User Management Module (UMM), System Security Module (SSM), Question Bank Management Module (QBMM), Test Set Management Module (TSMM) and Project Management Module (PMM).

DSMM stores data related to schema given by system coordinator. This module is used by QBMM, TSMM or can be operated individually in response to authorized users. UMM is the hub of all user related functionality and interactions to other modules of system and are used by actors. It relies on SSM for authentication and authorization. SSM is the host of all security functionality of the system. It provides an abstract layer over other modules to protect them from external harm. QBMM deals with both executable and non-executable question managements and also schema management. Thus it has three sub-modules, Schema Management Sub-module, Executable Question Sub-module and Non-executable Question Sub-module. TSMM is responsible for creating and monitoring test sets. Test sets are built from schemas and questions supplied by QBMM. TSMM has two sub modules, one is for executable questions and another is for non executable questions. Project Management Module (PMM) helps students and instructors to submit and evaluate projects.

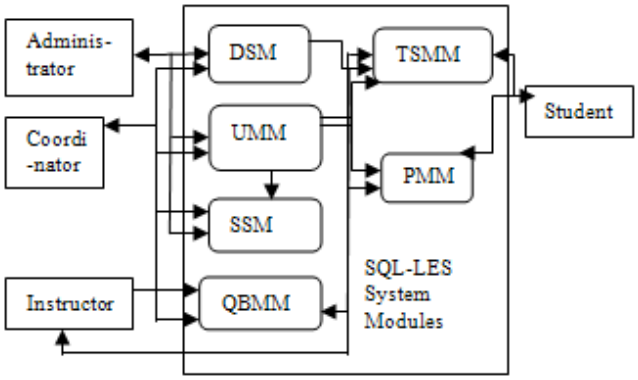

Fig. 1. System architecture of SQL-LES.

A. User Management Module (UMM)

In the system, there are 4 types of users: administrator, coordinator, instructor and student. UMM gets the authentication and authorization from SSM and send necessary information to TSMM, PMM and QBMM upon request. UMM can also register a user to the system and thus it can send and receive user information to or from SSM. Administrator can also modify a user and block or unblock a user. User can also access his full profile via UMM. The UMM has a function that fetch user auth info from SSM.

B. Data Set Management Module (DSMM)

SQL-LES contains preloaded datasets for creating new questions or update existing questions in the question bank. It contains a schema bank. Based on the schema bank, representative datasets are generated. It can also insert data to a table to be tested by student, can view current data and provide analysis and report on current data set, can export data as a CSV file (with help of UMM to determine the current user has the right to do the operation) and with support from SSM, can provide additional security over DSMM.

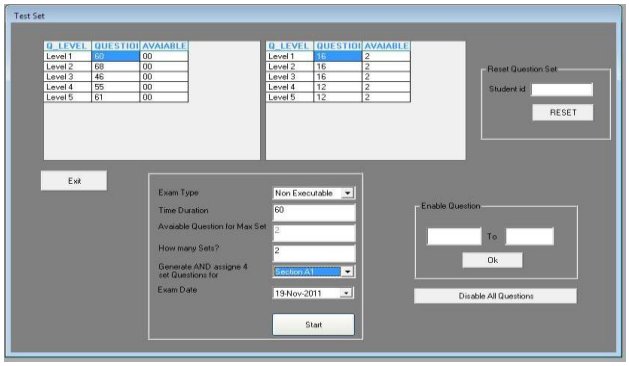

Fig. 2. Test set generation.

C. Test Set Management Module (TSMM)

Using these module teachers can create test sets as shown in Fig.2 for student examination on SQL, assessment and practice. This module depends on QBMM module for questions. It fetches questions from QBMM and generates test sets. A test set can be assigned to every individual student in the class; time can be set and managed. Instructors can monitor every submission of the students.

The instructor can download the total class performance of all the students and give to the students just after the class is over. Sometime, the students claim that their submission was correct but the system has evaluated wrongly. The test set monitor sub-system (Fig. 3) keeps all submission of the students and the selected information.

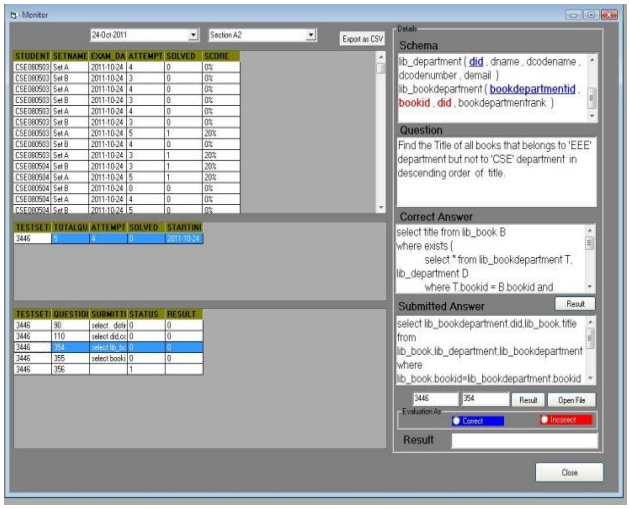

Fig. 3. Student's performance monitor page.

The step for creating a test set is given in Fig. 4.

1. *Check the available questions for each level*
2. *If available question for MAXSET is 0 go to step 7*
3. *Input test duration*
4. *Input number of question sets*
5. *set examination type*
6. *If validation success then test set is created*
7. *Need to add some more questions or activate existing questions from bank. Goto 3*

Fig. 4. Steps to create a test set.

This module deals with 2 types of test sets. Namely, Executable test set and Non executable test set. Executable test sets deals with executable questions. An executable

question can be evaluated automatically by the system. As for example, SQL questions are executable type. TSMM deals with question setup, test set creation, test monitoring and test result. When a student log in into the system, he finds the test set assigned to him by the instructor. Fig. 5 shows the screenshot of a test set assigned to a student. The student can view the question, the SQL schema with data types and the relational schema. He can perform all kinds of checking whether his solution to the SQL problem given to him is correct or not. After all kinds of checking, he submits the solution and gets an instant response whether his given answer is correct or not.

Non executable test sets mainly handle database design problems and PL-SQL. Fig. 2 shows the screenshot for creating of both executable and non-executable test sets. For appearing into the test, student needs to log in into the system and find his appropriate test set (Fig. 5). Student submits the answer of the question and can validate every submission whether it is correct or not.

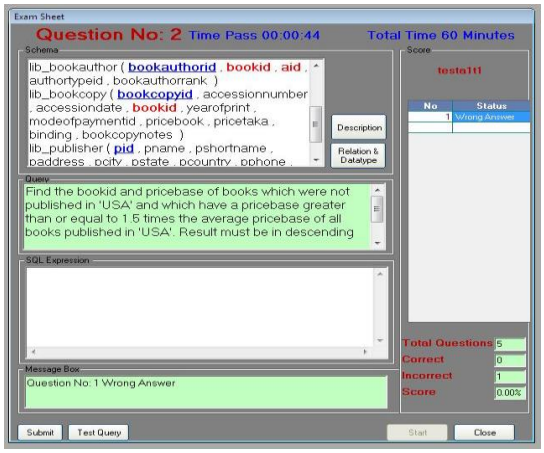

Fig. 5. Student examination.

D. Question Bank Management Module (QBMM)

A question bank is the storage of questions related to a topic (in this SQL), where these questions are related to a schema stored in the schema bank of the system (Fig.6). QBMM module stores the schema, related Entity Relation Diagram (ERD)'s, and relations in system. This module serves other modules and used by instructor to create question sets based on a specific schema. Instructors can assign for each question a complexity value that is used for test set creation.

The algorithm for creating a new SQL question for the question bank is given in Fig. 7.

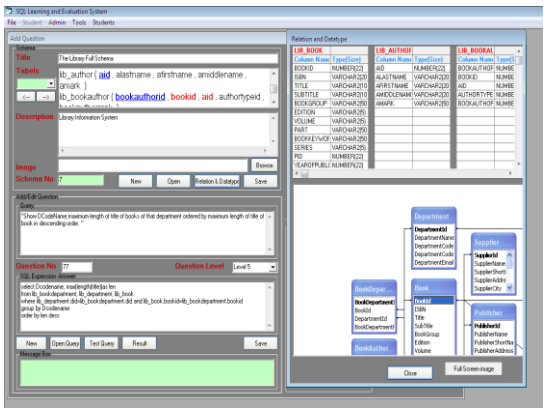

Fig. 6. Adding a new question in SQL-LES.

```
If schema exists() then    Add new image
   If image valid () then Add schema information
Save schema
Else
    Add new schema()
Endif
If new query () then    Add query, sql expression answer in the system,
   Add question level (1 – 5) and  Test query if needed
Else
   Open query from the system, Update sqlexpression answer
   and Set question level (1 – 5)
   Test query if needed
Endif
Submit question
Return success
```

Fig. 7. Algorithm for creation of a new question in question bank.

The QBMM module has the two sub-modules, SQL executable module and non-executable module. The purpose of SQL executable module is to deal with those questions which can be executed by the system. In this case, system can fully determine that the learner has given a correct solution or not. The executable module has two sub-modules, Schema Bank and SQL executable question bank.

Non executable module serves those questions that cannot be solved automatically, Such as database design, PL-SQL functions and procedure evaluation. In this case, these solutions have to be checked manually and evaluated by instructor. In general, QBMM deals with schema and questions that are put to test the learning.

E. System Security Module (SSM)

It is an internal module that works throughout the system to provide enhanced security on data and programs executed inside the system. SSM has user security layer which works with UMM, project security layer which works with PMM and SQL security layer that works when there is a SQL execution on system or when an SQL related information is storing in system. This sub module checks the SQL statement and confirms that this SQL statement will not harm the system.

For data sets security, SMM applies SQL security level while communicating with data storage (either database or configuration files required for a DSMM operation) and it help building improved security with Database server (in this case as we are using oracle security services) by adding some upper layer functionality for developing intelligence data security.

F. Project Management Module (PMM)

PMM module deals with managing the projects throughout a semester. Its sole purpose is to automate the project activity management and communicate with other modules if necessary. This module is used by admin, instructors and students. Admin supervise the whole process while instructors and students communicate and transfer different state in this module. State refers to submission of project designs, reports and presentation during the tenure of the project.

A project requires a strong evaluation process during a course like database system design. A project demonstrates how a student can handle a real life problem with the

knowledge he learned from the course. Evaluation of project is a difficult task as there are many process and artifacts to control. The PMM helps an instructor to handle these tasks. The necessary steps taken by the PMM Module are commencing project session, submissions of project list, creating project group by student, assignment of project supervisor, assign projects to group, project submissions, and Project evaluation.

III. SQL-LES as a Learning and Evaluation Tool

SQL-LES can be used as a learning as well as evaluation tool. One of the problems of learning of simple to complex SQL queries is the availability of proper dataset based on properly designed schemas for practice. In SQL-LES, we have developed about 11 database schemas and about 350 SQL questions in the question bank. An instructor can use the question bank for learning purpose by creating a test set as per duration of the class period. The test set can be assigned to the students and the students will try to solve the problems as per guidance of the instructor. Students can use all online and offline learning resources. The whole learning process will be a problem-based e-Learning system. As the learning process is problem-based, it will enhance the problem solving capability of the students and encourage the students for self-learning.

SQL-LES can be used as an evaluation tool for students' performance in the course. It can also be used as a management tool for students' activities.

IV. Effectiveness in Classroom Environment

SQL-LES has extensively used in the undergraduate database laboratory course in the Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology. The most important component of relational database management system is SQL. We have used the system to teach SQL using the question bank, dataset and existing test sets. We used the system to judge the performance of the students in SQL by creating 4 test sets beginning with the simple SQL on single table to complex SQL on multiple tables. Evaluation of each assignment was done automatically by the system and thus reducing the teacher's workload.

We designed two assignments on PL/SQL and assigned them to the students to solve the assignment in the allotted time period and submit the solution using the non-executable module. The evaluation was done semi-automatically by providing the answers to the system and a manual comparison of the correct answer stored in the system and the provided solution by the student. We applied the system to manage the entire database course projects assigned to the students. We broke up the project activities into six parts and four of them were to solve individually and the remaining two were integrating the individual components. Sixty percent of the evaluation was based on the individual performance. It improves the overall learning capability of the students.

V. Comparison with Other Systems

SQL-LES can be compared with SQLZOO [12] which is used for learning of SQL. SQLZOO cannot be used by the instructor to create test sets and assignment of the test sets top the students. It cannot be used in classroom environment. We have used SQL-LES in the classroom environment for the database laboratory course. Table I shows a comparison between SQL-LES and SQLZOO.

TABLE I: Comparison between SQL-LES and SQLZOO

Item	SQL-LES	SQL-ZOO
SQL Learning	Yes	Yes
SQL self testing	Yes	Yes
SQL test set for student evaluation	Yes	No
Schema Bank	Yes	No
Design Learning	Yes	Yes
Design test set for student evaluation	Yes	No
Database student project management	Yes	No

The reduction of instructor's workload to conduct the different components of the course is shown in Table II. We have considered a class of 30 students. Without using SQL-LES, we would require 3 teachers for evaluation of class assignment within 1 to 1.5 hours. Every student would need to create his own schema and insert data into the tables that would require longer time which is a misuse of class period. The total time for learning has been increased significantly because the time for creation of schema by every students and insertion of data by every student has been saved by the creation of question bank and schema bank and populating the schema by data sets.

Without using SQL-LES, the teachers would need to evaluate the solution of the assignments by every student manually. It is annoying for the students because the students had to incur a long average waiting time. The same was true for design problems. Using SQL-LES, the design assignments can be evaluated semi-automatically with a zero waiting time for the students. Individual project components submission in real time and evaluation by the teachers' offline also reduces the student waiting time.

TABLE II: The Reduction of Instructor's Workload to Conduct the Different Components of the Course

Item	Teachers Load with SQL-LES	Teachers Load without SQL-LES
SQL assignment preparation with data set	30 Minutes	5 hours (avg.)
SQL student assignment evaluation	No extra time is needed	Yes
Number of SQL learning in a 3 hours class	Average 30	Average 10
Design problem evaluation	50%	100%
Individual project performance evaluation	60%	100%
Project group performance	100%	100%
Overall	40%	100%

VI. Conclusions

E-learning has been using extensively in distance learning. The use of e-Learning in engineering education is a difficult problem. Students have lost interest in conventional

paper-based learning. Problem-based learning is an attractive solution to motivate the students to self-learning. The introduction of e-Learning with effective PBL can improve the student's participation in class room learning, more effective learning and develop the problem solving capability of the students.

In this research, we analyzed the database course in undergraduate level and found out the areas where we can apply the problem-based e-Learning technique. We have found that the laboratory classes of database course can be the most suitable candidate for this purpose. We have divided the course into three parts: the SQL, the PL/SQL and the database design. We have implemented SQL Learning and Evaluation System (SQL-LES) to cover the above three parts of the course. SQL-LES can be used for both learning and evaluation purpose.

We have developed a SQL question bank that contains the solutions of about 350 simple to very complex SQL queries based on eleven database schemas. The schemas are stored in schema bank in such a way that the instructors are free to add new questions in the question bank using the schemas with the approval of the coordinator. It is interesting to note that all students' activities are preserved in the system for future learning and evaluation.

PL/SQL problems and database design problems are non-executable type and we have designed the non-executable question bank in such a way that the system can effectively be used for learning and evaluation of these parts of the course. We have applied SQL-LES in the undergraduate level of database laboratory course and found it very effective for both students and instructors.

VII. Future Work

The present system evaluates the SQL queries as correct or incorrect. No partial evaluation can be done using the system. Also there is no global complexity value of SQL problems in the present system. Teachers assign the complexity value during the creation of question bank. Analyzing of the SQL queries and the results, a model can be developed for assigning a global complexity value of the SQL problems. The same model can be used for partial evaluation of submitted SQL solutions. The project management module can be redesigned to use it as a project-based learning tool.

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