

DEVELOPMENT AND EVALUATION OF COMPUTER-
BASED QUALIFYING EXAM FOR INCOMING
MECHANICAL AND ELECTRONICS ENGINEERING
STUDENTS

Dr. Jake M. Laguardor*

Engr. Rommel J. Pureza*

Abstract:

This study aimed to develop a Computer-Based Qualifying Exam (CBQE) for Incoming Third Year Mechanical and Electronics Engineering Students at Lyceum of the Philippines University (LPU). It also intended to evaluate the acceptability of the software project in terms of accuracy, content, style, navigation and usefulness. The study used software developmental research design and Waterfall model. The researchers used Microsoft Visual Basic 2005 as the programming language to develop the system and Microsoft Access 2003 for the creation of the database. The respondents of the study who evaluated the project were the faculty members and engineering students from the College of Engineering at LPU. Results showed that CBQE was generally acceptable in five criteria of evaluation. Faculty members rated the software higher than the students and the software needs more enhancements on its content and accuracy based on the result of the evaluation.

Keywords: software development, waterfall model, computer-based exam, qualifying exam, Lyceum

* Lyceum of the Philippines University – Batangas City, PHILIPPINES

Introduction:

Computer technology aids to provide improvement in the way people will be satisfied by the present enhancement in old – age process of getting things done. Interest in the educational use of information and communication technologies (ICT) in higher education is increasing (Deutsch, et al 2012). The enormous increase of computer utilization in education prompted the researchers to pursue a software development study in which students in the academe are the major beneficiaries. Computer based exams (CBE) are utilized to provide the students immediate feedback on their mistakes, to enable them to achieve mastery of the material learned and the effort required from the instructor is usually less than when using traditional exams because the grading of CBE is done mainly by the computer (Shacham, 1999).

Qualifying examination is being given to screen the qualifications of incoming third year students who wanted to pursue board degree programs in LPU such as BS Mechanical Engineering (BSME) and BS Electronics Engineering (BSECE). During summer in the month of April, College of Engineering is consistently providing this examination in a manual process of paper – pencil test. With the development of Computer-Based Qualifying Exam, it would be easier for the college to administer the exam wherein the examinees' information and the result of their exams will be stored automatically in the database of the system. This study will find ways to lessen the time consumed in preparing the questionnaire, conducting and checking the qualifying exam. It would also minimize the use of human resources and eliminate error in the generation of the exam result.

The study used software developmental research design which aimed to develop a computer based qualifying exam for incoming 3rd year BSME and BSECE students. It is intended to assess the developed software in terms of its accuracy, content, presentation, navigation, and usefulness of the material. The results of this assessment led to the proposed re-engineering of the manual process of conducting the Qualifying Examination to provide a more efficient student support service.

Method:

This study used the software developmental research which aimed to create a system that would enhance the manual paper – pen approach of taking Qualifying exam for incoming Third Year Mechanical and Electronics Engineering students at LPU. It also utilized the descriptive type in evaluating the acceptability of the software. The target respondents of this study were the students and faculty members of College of Engineering at the Lyceum of the Philippines University who were asked to evaluate the proposed system.

Beizer (1990) stated that testing is the act of executing test to demonstrate the correspondence between an element and its specification. Myers (1979) defines testing as the process of executing a program with the intent of finding errors. The proponents of this study used both meaning of testing to ensure that the new system will work properly. The study used survey questionnaire in the evaluation of the system. The instrument was adapted from the studies conducted by Aureus, Tabuzo and Escario (2005) regarding the validity and effectiveness of instructional materials in Mathematics. Some modifications and revisions were done to make it more suitable for the present study.

Research Design

The proponents used the Waterfall model in developing the software (Sommerville, 2001). The waterfall model presents a very high level view of what goes on during the development, and it suggests to developers the sequence of events they should expect to encounter.

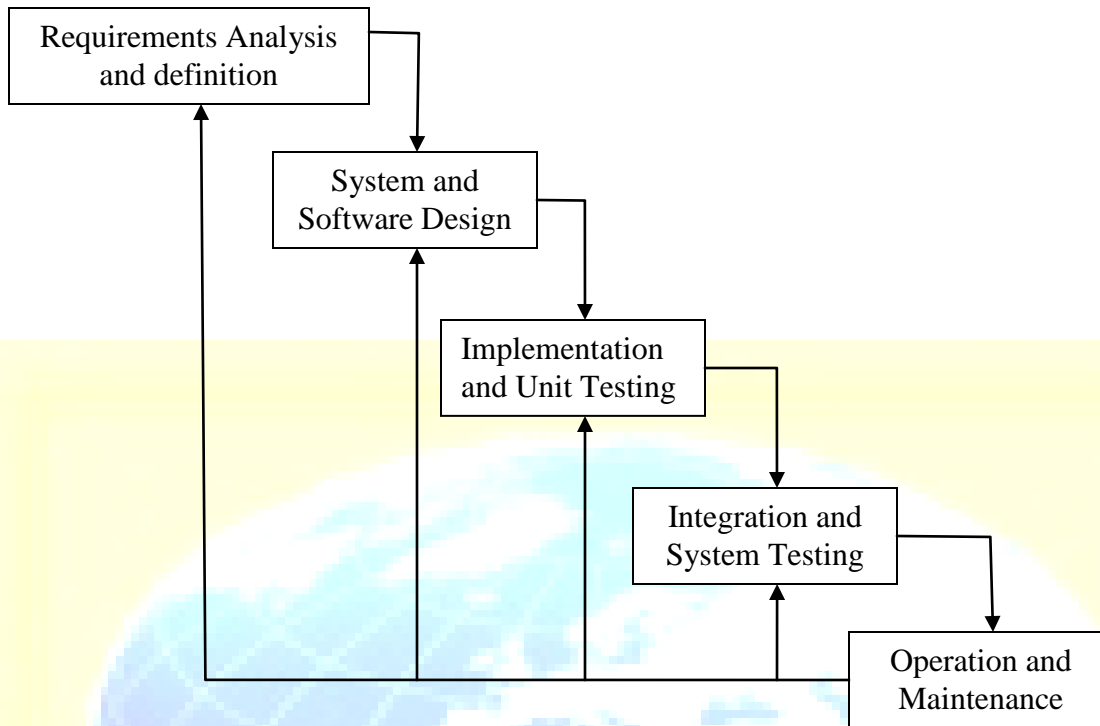


Figure 1. Water Fall Model

Procedure

This study followed the procedure of developing system software through defining and analyzing the requirements of the system and the hardware and software requirements.

Requirements Analysis and Definition

The researchers established the system's services, constraints and goals by consulting with the system user, the College of Engineering of the Lyceum of the Philippines University-Batangas. The complete description of the functions to be performed by the software specified in the software requirements specification developed by Japenga (2008) the potential users to determine if the software specified met its needs or how the software must be modified to meet its objectives. These requirements are defined in detail and serve as the system specification.

User Requirements:

- The CBQE must provide a questionnaire that is easy to navigate and the system must automatically check and calculate the result of the exam after the examination's time limit of four hours.
- The CBQE must have a registration process where the student number of the examinees will be taken as well as their names, and the major degree program they're planning to pursue.
- The CBQE must have a database for all the information that will be gathered on the examination such as students or examinees' information, exam questions and exam results.
- The CBQE must be a client-server system. The software must be used on computers called client side computers that are connected to a server computer that has all the stored data like questionnaire and exam results.
- The system must provide security features against intruders while allowing high level access to the Administrator who needs to change the settings and any information stored on the database of the system.
- The system must have a window that shows the result of the exam of all the examinees.
- The CBQE must run on PC with Microsoft XP operating system and has 800X600 screen resolution.

System and Software Design

The requirements were categorized to hardware or software requirements where the overall system architecture is established and the actual coding is done. Based on the requirements gathered, the researchers identified the tasks used to meet those requirements. The researchers used Microsoft Visual Basic 2005 as the programming language to develop the system and Microsoft Access 2003 for the creation of the database.

The proponents divided the system into five parts and these are the database, networking, registration, examination and result. The database using Microsoft Access 2003 was created and would make it available to university network where the database can be accessed by the client computers. The database has three tables; "AdministratorTable", "Questions" and "StudentInformationTable".

Table 1. Administrator Table

Field Name	Data Type
FirstName	Text
LastName	Text
MiddleInitial	Text
UserName	Text
Password	Text

Table 1 shows the information stored about the administrator. A field name with a text data type accepts only strings or alphanumeric information. The first name, last name, middle name, user name, and password of the registered administrator are stored on the FirstName, LastName, MiddleName, UserName and Password field name respectively.

Table 2. Questions Table

Field Name	Data Type
Questions	OLE Object
CorrectAnswer	Text
QNum	Number

The *Questions* table in Table 2 is the storage of all the questions of the CBQE. A field name has a data type of OLE Object can accept binary data. Each question might have images on it, thus OLE Object data type was used to accept this type of data. Data type Number can accept only numbers. Questions, correct answer for the question and the question number will be stored on Questions, CorrectAnswer and QNum field name respectively.

Table 3. Student Information Table

Field Name	Data Type
FirstName	Text
LastName	Text
MiddleInitial	Text

StudentNumber	Text
NumberCorrect	Text
DateTake	Text
Score	Number
Remark	Yes/No
Course	Text

Table 3 contains the personal information of the examinees and their exam results. Data type Yes/No is the same as Boolean data types. Remark field name indicates if the examinee passed or failed the exam. Remark Yes means passed and remark No means failed. The examinees' first name, last name, middle initial, student number, number of correct answer, date they took the exam, score, remark and the chosen course they selected were stored in FirstName, LastName, MiddleInitial, StudentNumber, NumberCorrect, DateTake, Score, Remark and Courses fields respectively.

The image shows a screenshot of a web-based registration form. The window title is "register". The form is titled "Register" and contains the following fields:

- Student Number: A text input field.
- Last Name: A text input field.
- First Name: A text input field.
- Middle Initial: A text input field.
- Major Course: A dropdown menu.

A "Continue" button is positioned at the bottom right of the form area.

Figure 2. Registration Form

Figure 2 is the registration form of the CBQE. This has four textboxes, one list down box and a button. This form is connected to the database and the information which will be entered on this form will be stored on the *StudentInformation* table. The four textboxes serve as the input boxes for the student number, last name, first name, and middle initial of the student. The chosen course of the student is a required field in the registration process. A student can select course on the *listdown* box which contains ECE and ME courses only.

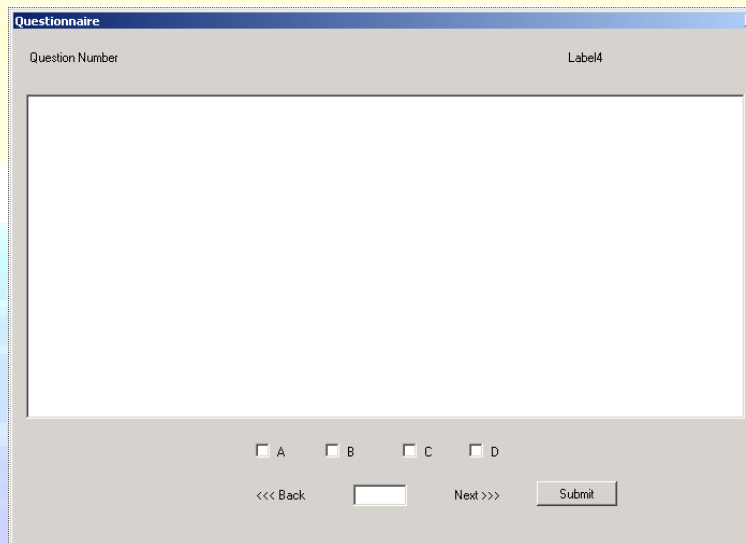


Figure 3. Question Form

This is where the examinees read and answer each question. This form has a *richtextbox*, a component capable to display the question inside the *Question* table of the database. The proponents used four checkboxes for the answer selection, the labels for navigation and the button for the submission of the exam. The result of this exam will be stored on the *StudentInformationTable*. On this design, the student can go to the next question by clicking 'Next >>>' or go to the previous question by clicking '<<< Back'. If the students want to submit the exam, they need to press the 'Submit button' and after clicking the button, the result of the exam will be displayed on screen.

Figure 4. Result Form

Figure 4 shows the table of the result of the examination. This form has a searching option to the result of the examination categories and filters. The searching option can be based on student number, date of examination, chosen course and remarks. If the administrator wants to view all students who passed the exam in a particular course, the administrator can check the textbox labelled 'Course Remark'. Using this option, the administrator can select a course either ME or ECE on a dropdown list labelled as 'Courses' and the remark either Passed or Failed on a dropdown list labelled as 'Remark'. The data is taken from the StudentInformation Table of the database.

Implementation and Unit Testing

During the implementation and testing stage, each part of the system is being tested to verify the functionality and to determine whether all its specifications were met. The proponents used

several steps in testing the system and these are function testing, performance testing, acceptance testing and installation testing.

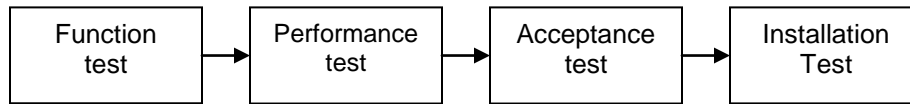


Figure 5. Testing Steps

During function testing, the researchers concentrated on the system components and the interaction of the program. This step ignores the system structure and it only focuses on functionality of the system. After the proponents determined that the system performs the functionality per requirements, they tested on how the functions performed. After the function and performance testing were conducted, the researchers were convinced that the system met all the requirements specified during the initial stage of CBQE development. The researchers also conducted the acceptance testing through asking the Dean and the faculty members of the College of Engineering if they agree to the acceptability of the system. Installing the system on the computer laboratory of the College of Engineering was the final testing made. This type of testing ensured that the system worked as planned.

Operation and Maintenance

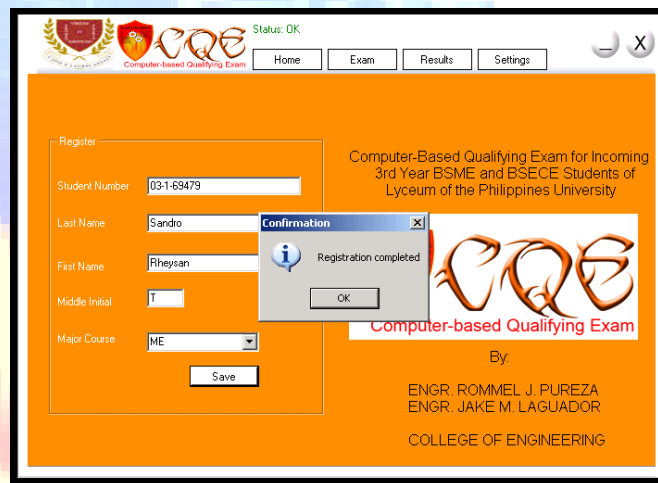
This is the longest life-cycle phase of the system development. CBQE was installed and put on its potential use. The CBQE was evaluated by the end-users who are the College of Engineering personnel that are assigned in conducting the qualifying exam and some students who served as the subjects for testing the system. The researchers used a survey questionnaire to evaluate the system. The result of the evaluation served to be the new requirements to enhance the system functionality and performance. On this phase, the College of Engineering personnel were trained by the researchers on how the system works and how to use it. The Dean of the College of Engineering served as the administrator of the program. The Administrator has the privilege to view the results of the exam, create and edit the questions on the exam. Setting up the client

program in the client computer and the program on the server side was also done by the administrator. Associated with training, the proponents included a user's manual for the operation of the CBQE. The process of correcting errors which were not discovered earlier in the stage of development was the last stage that was done to maintain the system which became part of system enhancement.

Results and Discussion

After all the studies and methods and the development process, CBQE was completely developed. The completed designed system of CBQE and the result of the survey conducted are shown.

System Design



The screenshot shows the home section of the Computer-Based Qualifying Exam (CBQE) system. The page has an orange background and a navigation menu with 'Home', 'Exam', 'Results', and 'Settings'. A 'Register' form is displayed with the following fields: Student Number (031-69479), Last Name (Sandro), First Name (Rheysan), Middle Initial (T), and Major Course (ME). A 'Save' button is at the bottom of the form. A 'Confirmation' dialog box is open, stating 'Registration completed' with an 'OK' button. The page also features the CBQE logo and text: 'Computer-Based Qualifying Exam for Incoming 3rd Year BSME and BSECE Students of Lyceum of the Philippines University', 'By: ENGR. ROMMEL J. PUREZA, ENGR. JAKE M. LAGUADOR, COLLEGE OF ENGINEERING'.

Figure 6. Home section

This is the home section of the program and this serves as the registration form for the students before taking the exam. The form on Figure 2 is the pattern used on this section. The student number, last name, first name, middle initial and the chosen course were the information needed in registering a student who would like to take the qualifying exam. These data must be entered in the textboxes as shown in Figure 6. Clicking the *Save button* will store the student information on the student database. A confirmation will appear if the registration was successfully completed.

The green text on the upper part of the program is the indicator showing the status of the system. The status “OK” means that the client and the server computer are connected to each other. The status “Error” means that there is something wrong with the system. The administrator can diagnose the problem on the Setting section of the program by setting the correct location of the source database as shown in Figure 16.

The program has four sections: home, exam result and setting section. In the home section, registration takes place. Taking the exam is done on the exam section as shown in Figure 6. On the result section, all the results of the exams are displayed as shown in Figure 14 and 15. Changing the location of the question database and student database are done in the setting section. The administrator can also diagnose the system if there is an error on the setting section as shown in Figure 16.

The examinees are only allowed to access the home section and the exam section because the result and the setting section are for administrator use only as shown in Figure 12.

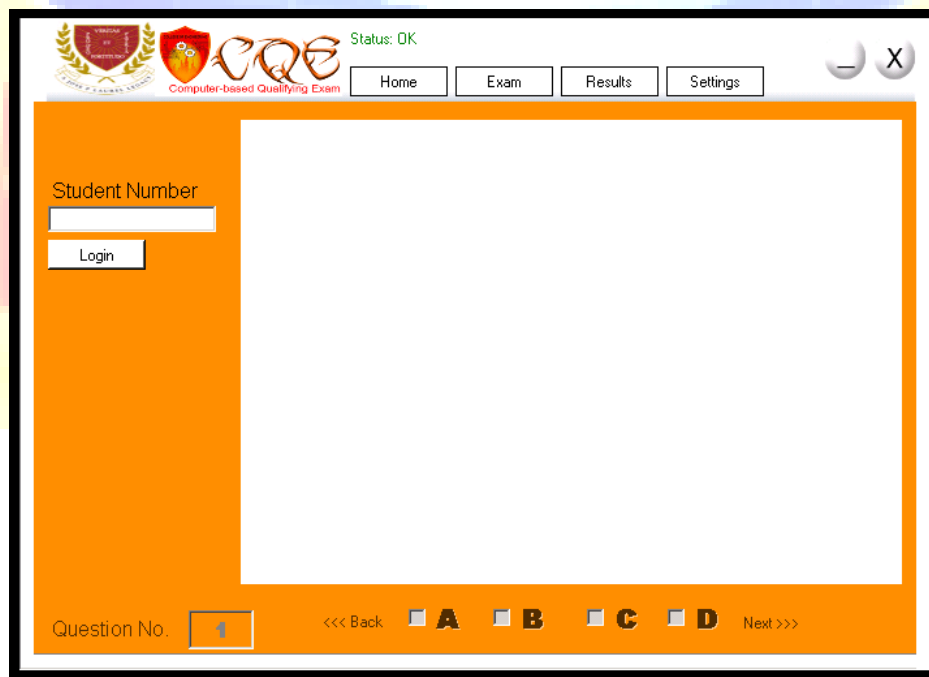


Figure 7. Exam Section (a)

On the exam section, the students need to enter their student number before they can take the exam. After pressing the *Login button*, the last name of the registered student will be shown on the upper left side of the form as shown in Figure 8.

The white portion of the form is the questions area where the question will be displayed. The check boxes on the lower part of the form labelled A, B, C, and D options are the choices that a student can select to answer questions. The exam is comprised of one hundred questions and each question can be answered by the student in an average of two minutes with a total time limit of four hours.

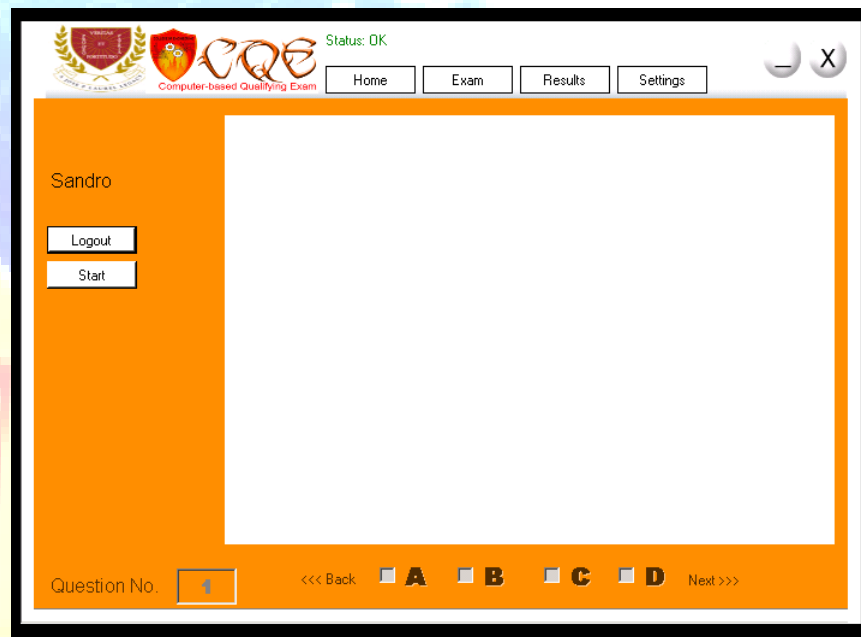
**Figure 8. Exam Section (b)**

Figure 8 shows that the start button must be pressed for the exam to begin and a confirmation will be displayed as shown in Figure 9.

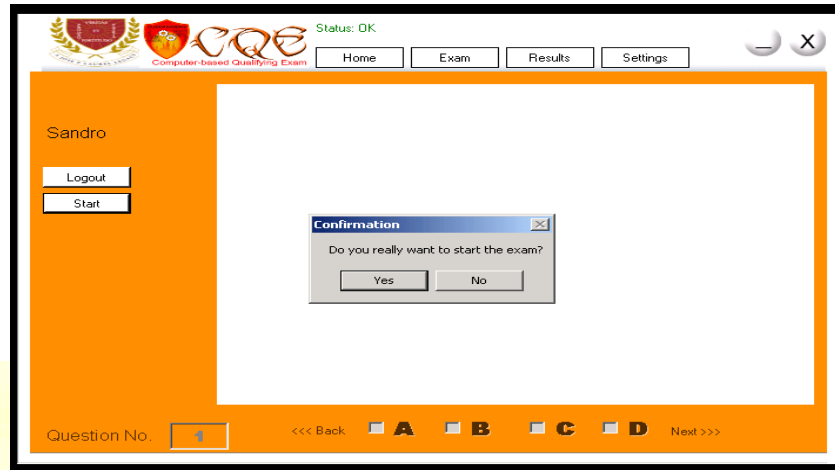


Figure 9. Exam Section (c)

This figure shows the confirmation asking if the student really wanted to start the exam. If the student selected the answer 'Yes' the exam will start as shown in Figure 10, pressing 'No', will show no changes on the exam section as shown on Figure 8.

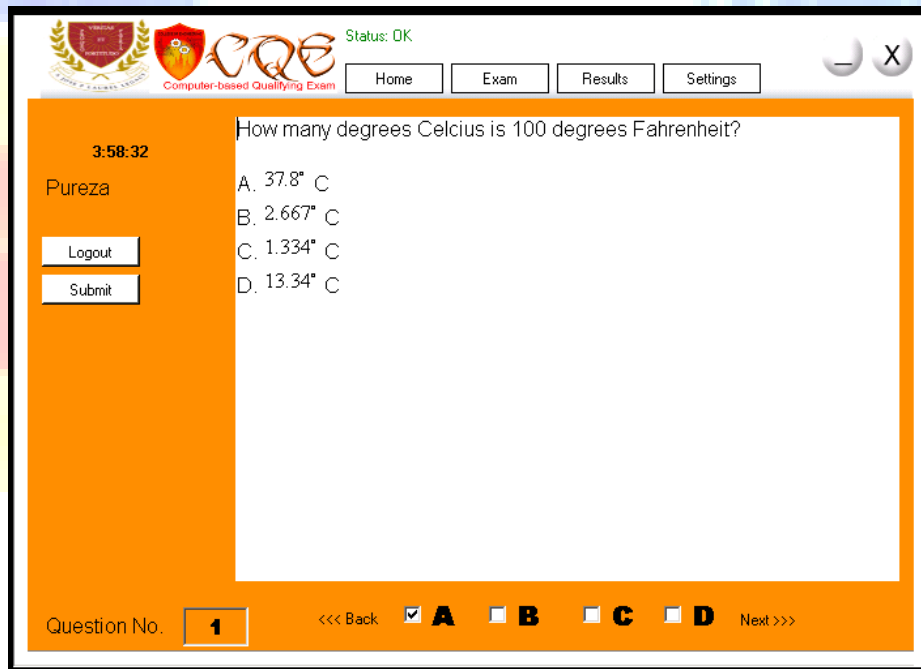


Figure 10. Exam Section (d)

On this figure, the exam is already starting. This will be shown only if the student decided to take the exam. The question shown on the Figure 10 is question number one. The question number is indicated on the text box with a label "Question No.". If the student wants to jump to question number 88, then the student can input the desired number on the question number box. If the student goes back to a previous question, the checked answer for that question will remain as its answer and when a student skips a question, the program will consider it a wrong answer. Since the exam has a time limit of 4 hours, a countdown timer on the upper left corner of the examination form will start when the exam begins.

A student can select an answer by checking the checkbox labelled A or B or C or D. Left and Right arrow keys can also be used to select an answer to lessen the effort of the examinee in selecting answers for every question. Going to the next question and previous question is done by clicking the 'Next' and 'Back' buttons or by pressing 'Enter' and 'Backspace' keys.

When the time reaches zero, the exam will automatically submit and the result of the exam will be displayed as shown in Figure 12. If a student wants to submit the exam even if there is still time remaining, he can click the 'Submit' button. A confirmation will show after clicking the 'Submit' button as shown in Figure 11. To continue submitting the exam the student can just click 'Yes' or otherwise click 'No'.

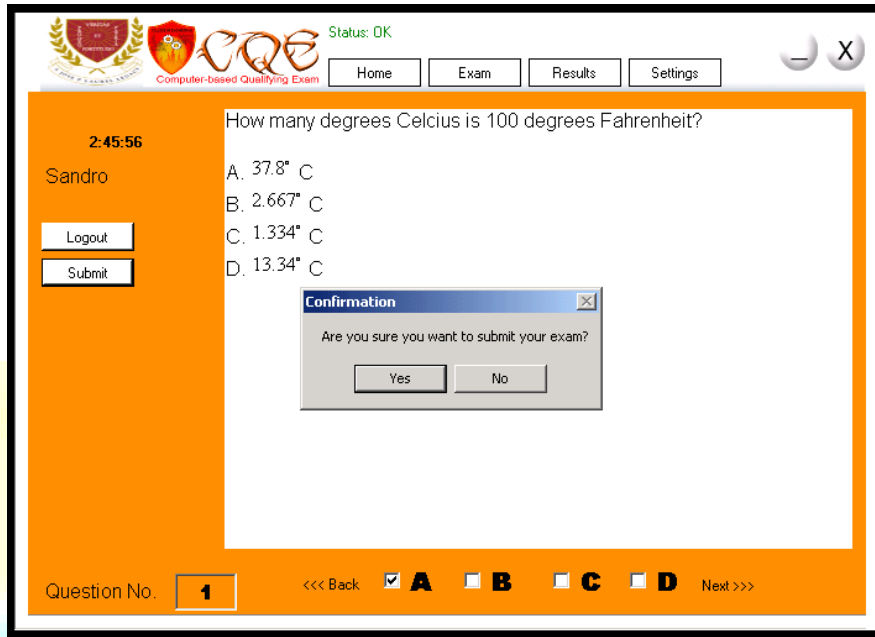


Figure 11. Exam Section (e)

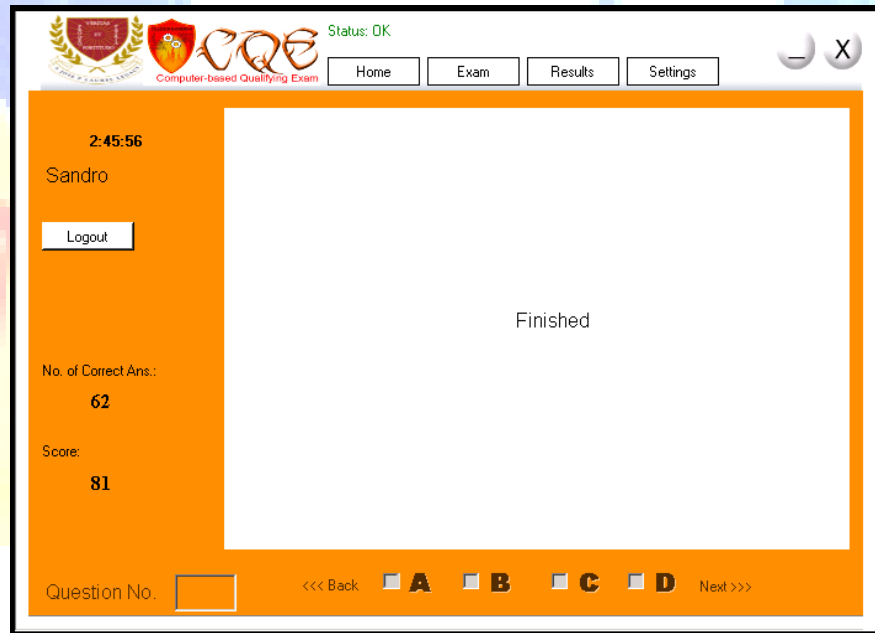


Figure 12. Exam Section (f)

On Figure 12 shows the result of the exam. The number of correct answers and the score/percentage were also presented. The formula used in getting the score or is shown below.

If correct answer is less than 51 then

$$\text{Score} = 60 + (\text{correct answer} \times (15 / (\text{total} / 2)))$$

If correct answer is greater than 50 then

$$\text{Score} = 75 + ((\text{correct answer} - (\text{total} / 2)) * (25 / (\text{total} / 2)))$$

This formula can generate a score of 60 for 0 correct answers, 75 for 50 correct answers and 100 for 100 correct answers.

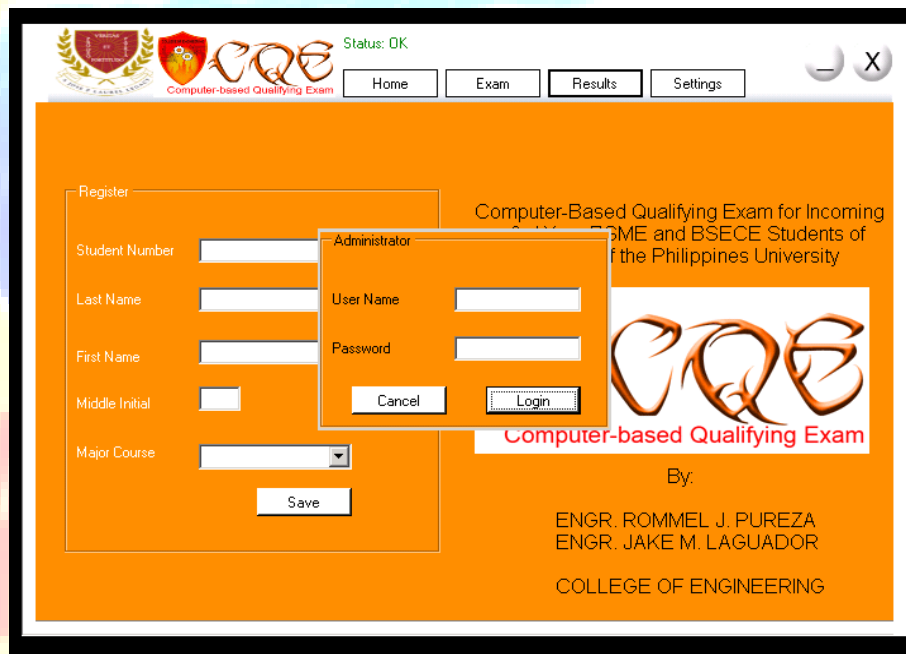


Figure 13. Result Section (a)

The result section can only be accessed by the Administrator. Figure 13 shows the Administrator login section asking for a user name and password of the Administrator. When the wrong username or password is entered, a confirmation will show saying that a wrong username of password was typed as shown in Figure 14. For a correct login, the admin will be directed to the result section as shown in Figures 15 and 16.

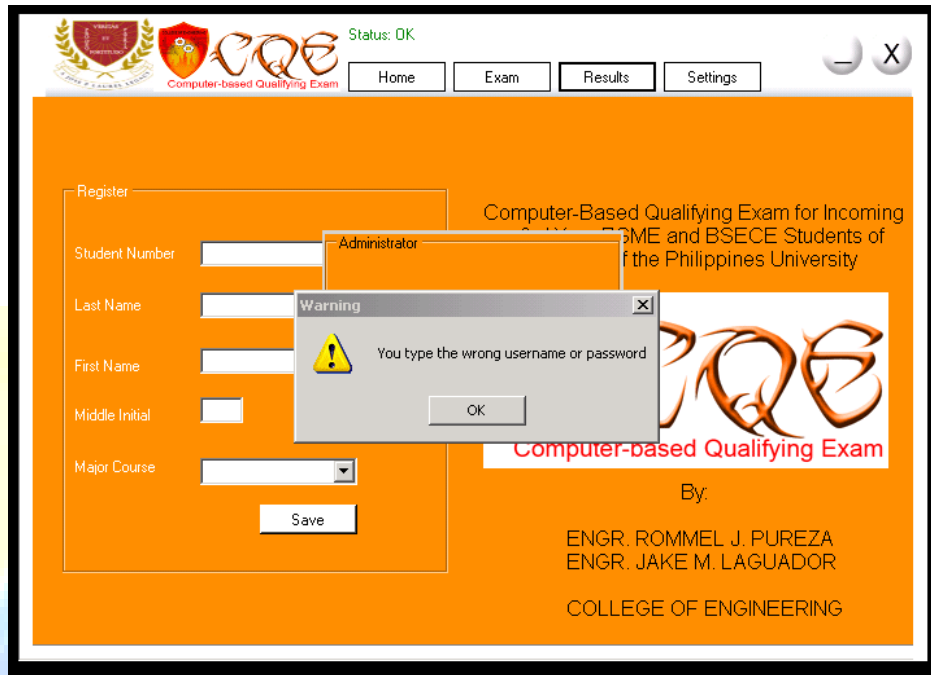


Figure 14. Result Section (b)

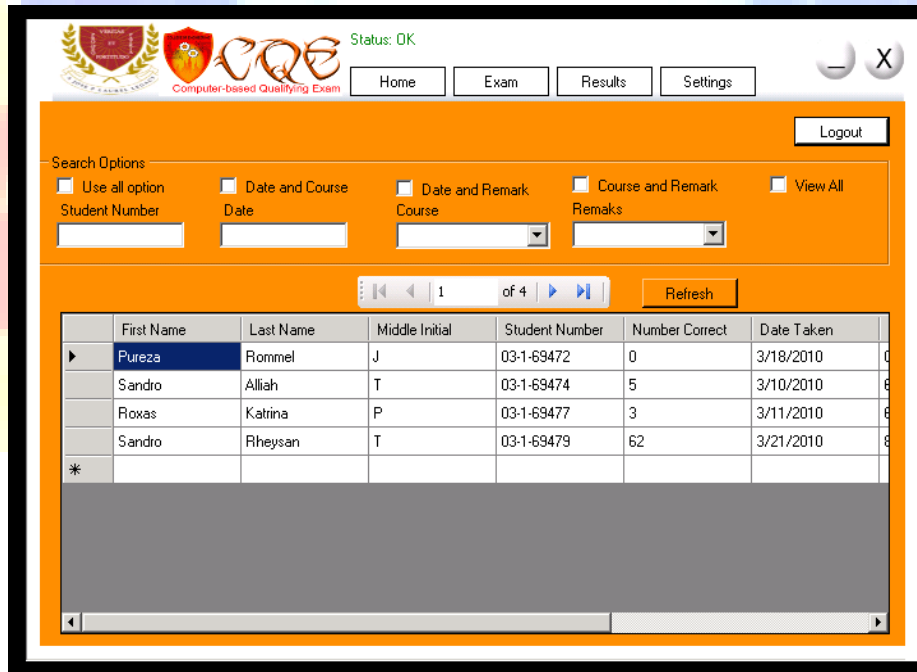


Figure 15. Result Section (c)



Figure 16. Result Section

The *Result Section* has a data grid where the results are shown. This data grid is connected to the student table of the database. This section also has a search option to filter the results and navigator buttons on the top of the data grid. The data grid has six field names and these are Student Number, Number Correct, Date Taken, Percentage, Remark and Course. These field names are shown on Figure 15. The check under the Remark field name represents the student who passed the exam.

If the Administrator wants to filter the results of the exam, the admin can use the searching option. If he wants to find a student who chose ME (Mechanical Engineering) and took the exam on a specific date, he can check the Date and Course check box to enable only the date textbox and the course dropdown list box and the Administrator can now type the date on the *date textbox*.

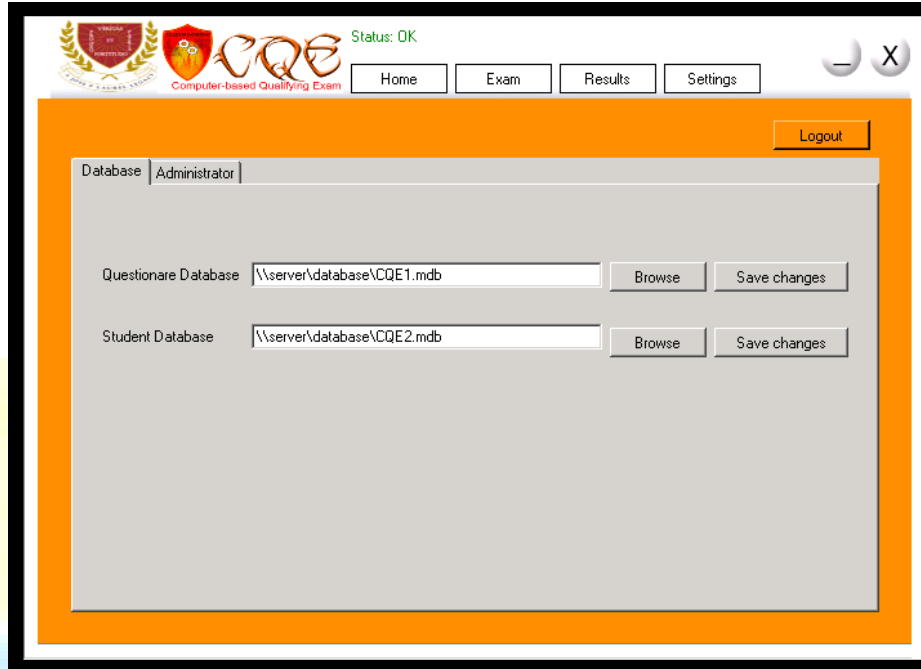


Figure 17. Setting Section (a)



Figure 18. Setting Section (b)

Figures 17 and 18 show the setting section of the CBQE. Figure 17 shows the database tab where the location of the database is set. The system is a client-server system because the client side program gets the questions from the server database and also sends results of the examination on the server database. Figure 17 shows that the program is set to read question and send result on the server computer named server. The Administrator can change password on the *Administrator* tab of the Setting section as shown in Figure 18.

Evaluation

Nine faculty members and thirty Engineering students of the College of Engineering at the Lyceum of the Philippines University – Batangas served as the respondents of the study. The result of the evaluation is separated into two sections; evaluation from faculty members of the College of Engineering and the evaluation from the students. The researchers used the Poll Survey component of Content Management System (CMS) software named Joomla in computing the results of the evaluation.

Table 4 shows the faculty members and students' evaluation on the Computer Based Qualifying Exam

Table 4. Faculty Members and Students' Evaluation on the Computer Based Qualifying Exam

Indicators	Faculty		Student		Total	
	WM	VI	WM	VI	WM	VI
The computed results of the computer – based qualifying examination is accurate.	4.89	SA	4.57	SA	4.73	SA
The developed software is protected from possible cheating and deception.	4.78	SA	4.50	SA	4.64	SA
There is no way for students/users to mislead the program to get the correct answer.	4.89	SA	4.43	A	4.66	SA
Cluster Mean	4.85	SA	4.50	SA	4.68	SA

Content

The CBQE sufficiently covers the topics specified.	4.78	SA	4.47	A	4.63	SA
The questions are presented from simple to difficult	4.89	SA	4.30	A	4.60	SA
The exam covers realistically the time limits	4.89	SA	4.43	A	4.66	SA
The questions are developed to evaluate critical thinking of the students	4.89	SA	4.33	A	4.61	SA
Cluster Mean	4.86	SA	4.38	A	4.62	SA

Style

The user can easily read the questions observing appropriate font color, size and style.	4.67	SA	4.53	SA	4.60	SA
The questions are well presented and free from errors.	4.89	SA	4.57	SA	4.73	SA
3. The choices are labelled and arranged properly.	5.00	SA	4.67	SA	4.84	SA
Cluster Mean	4.85	SA	4.59	SA	4.72	SA

Legend: SA – Strongly Agree; A – Agree; MA – Moderately Agree; D- Disagree; SD – Strongly Disagree

Table 4. Faculty Members and Students' Evaluation on the Computer Based Qualifying Exam (cont.)

Navigation

There is not much delay in the transition from one question to another.	4.89	SA	4.43	SA	4.66	SA
The user can easily view and go back to the numbers without answers.	5.00	SA	4.70	SA	4.85	SA
The user can choose the answer from the given options smoothly.	5.00	SA	4.50	SA	4.75	SA
The user can easily follow the set of instructions	4.89	SA	4.60	SA	4.75	SA

and directions in taking the examination.

Cluster Mean	4.95	SA	4.56	SA	4.76	SA
Usefulness						
The results of the exam can be printed easily	4.56	SA	4.63	SA	4.60	SA
The results of the exam can be determined immediately.	4.89	SA	4.57	SA	4.73	SA
The CBQE is the convenient way of taking and checking the exam of the students.	4.89	SA	4.60	SA	4.75	SA
The CBQE conserves the time and effort of the examination committee.	4.89	SA	4.43	A	4.66	SA
The software can also be used for other examinations aside from qualifying exam.	5.00	SA	4.80	SA	4.90	SA
Cluster Mean	4.85	SA	4.61	SA	4.73	SA
Composite Mean	4.87	SA	4.53	SA	4.70	SA

Legend: SA – Strongly Agree; A – Agree; MA – Moderately Agree; D- Disagree; SD – Strongly Disagree

The respondents strongly agreed that the developed Computer Based Qualifying Exam is Very Acceptable in terms of its Accuracy, Content, Style, Navigation and Usefulness with cluster weighted mean scores of 4.68, 4.62, 4.72, 4.76 and 4.73, respectively.

Engineering Faculty members rated the acceptability of the developed software higher than the ratings given by the Students in all criteria of evaluation. This can be accounted to the small number of faculty members which is only 9 who evaluated the software compared to the thirty (30) Engineering students involved in the evaluation. This also implies that students were the target end-users of the software and they really wanted to enhance it more to become very suitable for their needs.

Conclusion and Recommendation

Based on the results gathered, the researchers concluded that the Computer-Based Qualifying Exam for incoming 3rd Year BSME and BSECE students of Lyceum of the Philippines University is acceptable in five criteria of evaluation in terms of its accuracy, content, style, navigation and usefulness. Faculty members rated the software higher than the students. The software needs more enhancements on its content and accuracy based from the result of the evaluation. The researchers successfully tested the functionality of the system. Although according to the result of the study conducted by Peterson and Reider (2002) which showed that computerized testing weakens the perception of the certification/examination, perhaps because respondents indicate that writing skills and free-form problem solving should be included on certification exams, there should still be a manual computation that constitutes lesser percentage of the overall result of the qualifying exam and that is not anymore part of the scope of the study. Current computer based assessment models focus on the assessment of knowledge rather than deeper understandings, using multiple choice type questions, and blocking access to more sophisticated software tools (Byrnes & Ellis, 2006).

Questions used for the examinations were taken from the Dean of the College of Engineering and the validity of the questions included in the system is not anymore part of the objectives. The researchers ensured that the questions used in the system were undergone validation.

Although the evaluation result was very acceptable based on the result of the study, it is still hereby recommended to enhance the content of the software such as including more questions for random selection to prevent cheating during the examination. Font style and size of the questions must also be enhanced to make it more visible to the examinees. Faculty members from the College of Engineering may adapt this system software in designing their major examinations to minimize the time being spent in checking the exams although designing a computerized examination needs more to devote for preparation it would be more enjoyable for the students answering their major examinations out of the traditional paper-pen approach.

References

- Aureus, Alberto A, (2005). Validity of Powerpoint Presentation in Techniques of Integration: Teaching Strategy, Unpublished Master's Thesis, Eulogio "Amang" Rodriguez Institute of Science and Technology, Sampaloc Manila, Philippines.
- Beizer, Boris (1990). Software Testing Techniques. 2nd Edition. Van Nostrand Reinhold, Inc, New York NY,.
- Byrnes, R. & Ellis, A. (2006). The prevalence and characteristics of online assessment in Australian universities. *Australasian Journal of Educational Technology*, 22(1), 104-125. [viewed October 30, 2009]
<http://www.ascilite.org.au/ajet/ajet22/byrnes.html>.
- Deutsch, T. Herrmann, K., Frese, T., Sandholzer, H. (May 2012). Implementing computer-based assessment – A web-based mock examination changes attitudes, *Computers & Education*, 58(4), 1068-1075.
- Escario, Philip U. (2005). Effectiveness of Powerpoint Presentation on Some Application of Definite Integrals: A Teaching Strategy, Unpublished Master's Thesis, Eulogio "Amang" Rodriguez Institute of Science and Technology, Sampaloc Manila, Philippines.
- Japenga, Robert. How to write a software requirements specification [viewed January 13, 2010] available: <http://www.microtoolsinc.com/Howsrs.php>
- Myers, Glenford J. (1979). *The Art of Software Testing*. John Wiley and Sons.
- Peterson, B. K., & Reider, B. P. (Autumn 2002). Perceptions of computer-based testing: a focus on the CFM examination, *Journal of Accounting Education*, 20(4), 265-284.
- Sommerville, Ian (2001). Software Engineering 6th Edition, Pearson Education Asia Ltd..
- Shacham, M. (June 1999). Computer based exams in mathematical modelling and simulation courses. *Computers & Chemical Engineering*, 23(1), 649-662.
- Tabuzo, Victor T. (2005). Validation of Instructional Material in Teaching Polynomial Functions using Powerpoint Presentation, Unpublished Master's Thesis, Eulogio "Amang" Rodriguez Institute of Science and Technology, Sampaloc Manila, Philippines.