COMPUTER SYSTEM FOR ASSESSMENT CALCULUS AT ENGINEERING LEVEL

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ABSTRACT

We This article shows the importance that has the use of technology, in this case a computer system, which allows self-evaluations and assessments to students who are enrolled in the course of Calculus. The way of use is so flexible because its design based on pop-up screens, to highlight concepts or processes of problem solving, simulations that allow students to visualize concepts, review step by step application problems of calculus. In this research we found that according to the record of each student who used the system, this favored a more significant learning according to the time of use.
Keywords: Calculus, Engineering, Learning.

1   INTRODUCTION

The training of engineers is a factor directly linked to progress. In Mexico the demand for engineering education, ranks second, with 33% of the total enrollment. Menchaca (2009).

Some of the deficiencies in engineers training are deficiency of knowledge and practical skills, as well as the inability of teamwork.

Some topics of interest that are being addressed by experts in the education of engineers, are related to the Conceptual Knowledge, Skills Development and Interest training, (Resendiz, 2009, Streveler, 2008 and Redish, 2008). There are misconceptions that present engineering students in mathematics as the focus on algorithms and not on their physical interpretations, which has become a common practice and counterproductive among engineering students.

For these reasons it is necessary an analysis of topics in mathematics and the relationship between them with practical applications. The case presented in this article is the learning unit of 'Calculus' because it is one of the main courses found in the curriculum of schools of engineering at 'Instituto Politécnico' in Mexico (IPN, 2009), also for the high rate of failure showed in an IPN Unit statistics.

After selecting the course, multiple-choice questions were designed and a quantitative and qualitative analysis of the results were obtained, after that software was designed to support the learning of Calculus, emphasizing self-assessments and assessments which are divided into two categories. Easy to medium level and medium level difficult.

1.1   Problem Statement

Does adaptive assessment using calculation software strengthens meaningful learning of this learning unit?

1.2   Theoretical Aspects

It is important to show the stages of the research:

- Choose a subject / course based on a record in which students show deficiencies.
- Identify important issues in the course and the way these issues are linkied with advanced courses and industrial applications.
- Based on the analysis of the course, write questions with difficulty levels and conduct a field test.

Once the student finds a question and fails to solve it; he/she can review contents of Calculus within the system, whether readings, pop-ups windows, or a simulation that shows how to solve a similar problem.

1.2.1 First phase. Choose subject

The reason to work with calculus is its high failure rate at Escuela Superior de Cómputo (ESCOM). Instituto Politécnico Nacional (IPN). 48% in the second semester 2012, (January to june 2012).

In addition, students have deficiencies in working with Calculus, as in the case of:

- Overuse and difficulty remembering many algorithms for problem solving.
- Little development of logic - mathematic reasoning.
- Limited capacity of visualization working with graphics, to determine the domain, range, continuity, discontinuities among other properties of a function.

Moreover, there are currently few software tools that include simulations of the theoretical concept and an application in which students can apply what they have learned, self-assessments to know his/her level of

knowledge and how they have evolved.

A software tool is created that is able to generate random assessments based on the difficulty of the questions, sample activities that allow students to visualize concepts that help students their understanding. Students can know their level of knowledge through self-assessments to solve. The teacher can check the record of each of their students.

1.2.2 Second Phase. Identify important issues in the course and the way these issues are linked with advanced courses and industrial applications

Calculus is taught in the first semester at ESCOM-IPN, contents are divided into five thematic units according to the official program of Calculus approved at ESCOM-IPN.

Figure 1 shows the titles of each Thematic Unit of Calculus.

ACADEMIC UNIT **ACADEMIC PROGRAM:** Computer Systems Engineer **LEARNING UNIT:** Calculus **LEVEL** I **GENERAL OBJECTIVE:** Manage calculating tools to solve engineering problems of implementation through the development of exercises in a systematic, critical and reflective way. **CONTENTS:** I. Functions and Graphs II. Limits of functions and continuity III. The derivative and techniques IV. Integration Techniques and Integration as Riemann sums V. Transcendental Functions.

Figure 1 Content summary of each Thematic Unit in Calculus

The topics considered to have a high degree of difficulty according to the experience of teachers who have taught Calculus and based on previews research. [5] - [8], are:

- Real Numbers
- Inequalities
- Functions and its graphics
- Properties of functions
- Limits

These topics are related to other Learning Units given at ESCOM-IPN such as Differential Equations, Vector Analysis, Probability and Statistics and Communications Control.

After choosing the topics, questions were elaborated.

1.2.2　Third phase. About the Calculus questions made at ESCOM-IPN

88 questions were designed according to the topics selected in the previous phase, five reference textbooks were used because changes were made in order that the student is faced with situations close to their school reality.

Each question was solved by the technical manager of ESCOM and author of this article, in order to check the time taken for it and also to have an idea of the possible errors that students could make in their resolution and have them as one of 4 possible answers to select for each question.

The 88 questions were applied to a sample of 88 students taking the Calculus Learning Unit, belonging to the following six groups: 1CM1, 1CM2, 1CM3, 1CM4, 1CM5 and 1CM14.

Questions answered by students online are at: http://posgrado.escom.ipn.mx/posgrado/quiz

2   QUANTITATIVE AND QUALITATIVE ANALYSIS OF RESULTS OBTAINED BY APPLYING REAGENTS

The results are shown in the following charts.

Figure 2 shows Chart 1 which corresponds to the total of questions solved by the 88 students and provides the number of correct answers by question. The *x-axis* shows the number of students and y-*axis* shows the number of questions.

In Figures 3, 4 and 5 are charts showing some of the questions answered incorrectly by more than 75% of the sample of 88 students.

Question 7. Nonempty set endowed with a binary operation that satisfies the axioms of lock, association and inverse is called:

a) Semigroup.

b) Abelian Semigroup.

c) Group.

d) Field.

Only 5 of 88 students (6%) of students correctly answered this question, ie 95% of the sample are unaware that this set of real numbers with the characteristics mentioned in the same question is called Semigroup.
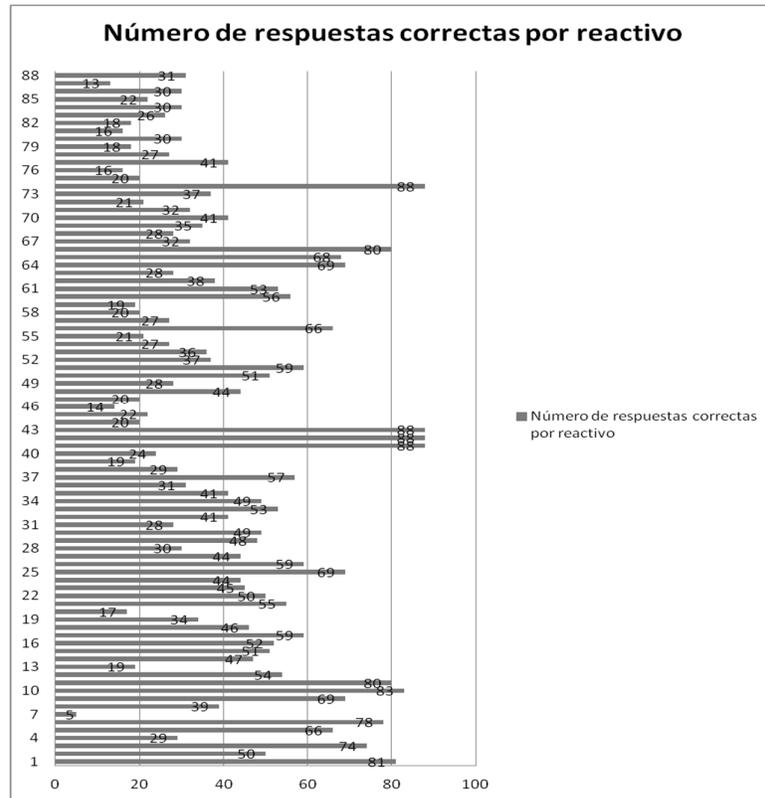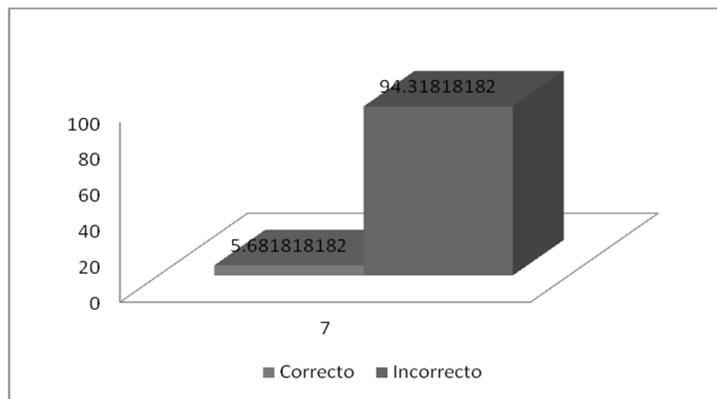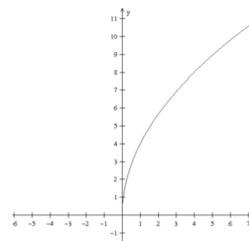
Figure 2. Questions Chart

Figure.3. Chart showing the correct and incorrect answers of question 4 belonging to the topic of real numbers

Question 20. Given the following graphic determine its algebraic expression

a) $f(x) = 4\sqrt{x}$

b) $f(x) = \sqrt{4 + x}$

c) $f(x) = 2\sqrt{4x}$

d) $f(x) = \sqrt{4x + 2}$

Only 17 of 88 students, ie 19% correctly identified the expression of the graphic, ie 81% of the students have not strengthened the relationship between algebraic and graphic record, in particular corresponding to stretches and displacement of a function.
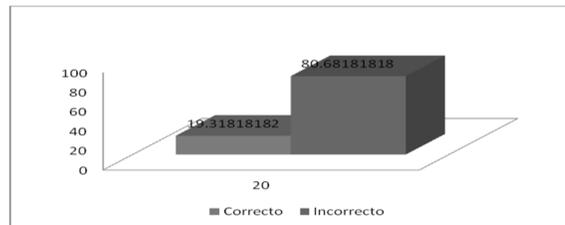

Figure 4 Chart showing correct and incorrect answers of question 20
belonging to the topic of functions and their graphs

Question 13

The graph of an odd function is:

a) Symmetric with respect to axis X

b) Symmetric with respect to axis Y

c) Symmetric with respect to the origin

d) Symmetric to a line parallel to the X axis

Nineteen of 88 students correctly solved this question, ie 92% of students do not recognize that an odd function is symmetric with respect to the origin.
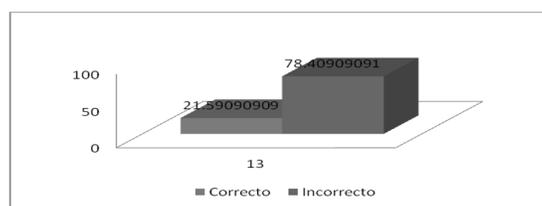

Figure.5 Chart showing the correct and incorrect answers of question 13

belonging to the topic properties of functions.

Note that in the calculation system there is an animation that shows this feature for the student to visualize the concept.

Charts were prepared for each of the 88 questions, that shows the amount of correct and incorrect answers.

Six charts were developed showing the correct and incorrect answers given by group, on the *x-axis* are the numbers of the questions and on the *y-axis* the number of students who solved correctly and incorrectly each question.

3   RATIONALE FOR THE DEVELOPMENT OF COMPUTATIONAL COMPUTING SYSTEM

There are currently few software tools that include simulations of the theoretical concept and an application in which students can apply what they have learned, self-assessments to know his/her level of knowledge and how they have evolved.

A software tool is created that is able to generate random assessments based on the difficulty of the questions, sample activities that allow students to visualize concepts that help students their understanding. Students can know their level of knowledge through self-assessments to solve. The teacher can check the record of each of their students.

3.1   *Calculation System Overview*

The development of this system concerning the subject of Calculus includes several elements in its content, which is divided into five main units, each unit with its respective subtopics.

It was planned to have available at all times the units menu, so that students have available the contents of any topic or subtopic that is of interest.

For the student to access the content area a click on the menu is sufficient, selecting the unit that is of interest, then it will display a list of sub-items for that topic, then the student must select the desired subtopic linked to the specific web page.

When selecting a subtopic the student will have a five options menu. Subtopic *theory*, which are notes placed by the teacher. Another option is the *solved problems* section, this section presents a number of approaches, but also shows the steps to get the result. The *proposed problem* section is a series of exercises aimed at the student to reach the result only. The *reading section* presents the theoretical content of the sub but in a PDF file, ready for students to see it online or download it to your computer and use it at a later time. The last part of the menu is *self-assessment* section, which will contain a series of assessments that students will have to perform, the results of these evaluations are stored in a database so that in this way the teacher can access the system and view results.

The content of each section consists of several elements, plain text, images, and animations, this in order to make more dynamic student learning.

3.2   *System Technical Manual (Calculus)*

Definition of functional requirements. There are two types of users: Teacher and student.

System users must authenticate themselves to access, depending on the privileges the system shows the options.

- The teacher sees the record of each student.
- The system generates random exams.
- The student evaluates his/her knowledge through self-assessments.
- The system stores the time it takes the student to solve the self-assessments.
- The contents of the units are divided into topics and subtopics.
- The student uploads a PDF file to the system with his/her procedures to solve its evaluation previously generated.

3.3 Model and technologies used

Due to the nature of the project, the calculation system was implemented on the web, taking the client - server architecture is based on the Model View - Controller (MVC) consisting of three parts:

- Model (Database).
- Controller (Business Rules or Program Logic, Middleware for storing data in the database).
- User interface (View).

4   CALCULATION SYSTEM IMPLEMENTATION

It was applied to a sample group of 38 students who were enrolled in Calculus Learning Unit at ESCOM-IPN.

How the student used the system is described according to its functionalities.

4.1 Home Screen

The Home screen is the first page of the website that the user sees. This page contains an introductory message to the user, explaining the content of the website in a brief.

In the footer there is the project name and the email address of the webmaster.

Figure 6 shows the way in which the content is organized in each of the units. With mouse hover each of the sub-themes display the corresponding content.

Figure 6. Organization of software content

Students of the sample signed up and the teacher kept a track record.

4.2 Use of Screen Pops

As shown in Figure 7 some examples were placed in screen pops, to see them, just click on the texts that appear in red throughout the website.

The following example shows how the solution of an example is divided into two cases and each of these is presented in a popup screen within the same browser.
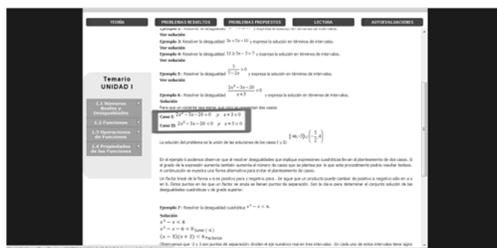
Figure 7. Solving an inequality shown in a popup screen

By clicking on any of the red text containing one of the pop-ups is displayed as shown in Figure 8. To return to content, just press the label "close X" that appears at the bottom right of all pop-ups.
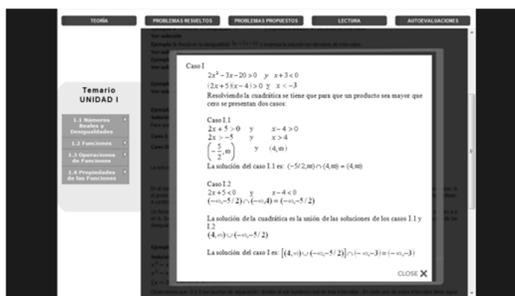

Figure 8. Pop-ups

4.3 Using Simulations

Some of the text in red refers to simulations, animations that are designed to make the concept more graphic. Figure 9 shows an example of an interval set, corresponding to the subtopic intervals and inequalities in Unit 1.

Figure 9. Computer simulation

The students in the sample used simulations which allowed them visualize some concepts that were able to build such as the derivative and limit.

The students responded with several self-assessments successes which show the progress achieved by them.

5. CONCLUSIONS

The development of the computer system of calculation led to several activities shown in this article, from the revision of the calculation curriculum, recognition of cognitive difficulties that students have, questions designing, implementation and analysis of all organization of content in the system and how it is presented. Responding to the statement of the problem, according to the record of each student who used the system, it favored a more meaningful learning that goes according to the time they used the system to study, the resolution of the self-assessments as a way to review their own learning and assessments of each unit, which were reviewed by the teacher and found that most students passed the course using this system.

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