REINFORCEMENT OF MATHEMATICAL CONCEPTS FOR HIGH SCHOOL STUDENTS DURING ALGEBRAIC, GEOMETRY AND CALCULUS COURSES USING COMPUTATIONAL AIDS

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Abstract

The present work is dedicated to evidence the importance of the new technologies to develop better teaching courses for the student of mathematic courses on high schools. The use of tutorials, graphical, visual and interactive presentations has become a powerful tool for teachers who teach math courses in high schools in Mexico. When computer aids were formally incorporated in classrooms in 90s an increment on the student's performance was observed. Although the understanding of math topics improved; nowadays the student's performance seems remaining in a stationary period; moreover, the students tends to forget many basic math concepts quickly especially if they do not continue practicing. Thus, the improvement of the teaching-learning process continues being a priority need especially for engineering students. Then some suggestions such as the increment of student's participation solving problems inside the classrooms and a modification on the teaching process focused to increase the student thinking time to create more intelligent solutions on math courses is exposed.

Keywords: Geometry and calculus lessons, computer supports, development of visual tools, Teaching-learning process, improvement on student performance.

1 INTRODUCTION

One of the most difficult courses for student during high school is mathematics. Students have many problems due to some mathematical concepts are abstracts and complicated to understand if they do not have a good previous knowledge. Some of the theorems are complicated to understand especially if some of these must be demonstrated. Mathematics for high schools students in Mexico is frequently divided on 6 courses; each one is dedicated to treat a specific kind of math topic. These courses are taught in 6 scholar periods respectively along 3 years. These courses are the following:

1. Algebra.
2. Trigonometry.
3. Statistic.
4. Analytical geometry
5. Pre-calculus.
6. Integral Calculus.

These courses are considered as basic for many purposes on all high schools and absolutely necessary for students who will continue their preparation in universities independently the studies they choose.

Mathematical courses are different to history, grammatical or other courses; here the student do not need memorize dates, names of people or facts; here the students must understand the problem and apply any method for solving. Thus these courses must be didactically planned with a different manner and with a different point of view.

The topics of mathematical courses have still remained almost without changes for many years. But the teaching methods have been in constant evolution according with the new technological possibilities and resources moreover new methodologies have also been developed in order to improve the students performance.
The mathematical courses for high school boys were established a long time ago, nevertheless the teaching methods must be updated according with the today needs. Moreover, computer technologies allow the development of more didactic and efficient courses for better understanding.

The need of imagination by the students frequently is assumed as a trouble for the teaching and learning process especially during complex courses such as mathematical courses.

Solving problems in a blackboard was the only limited resource for teaching these complexes courses in old times. Nowadays there are many sources to find a solution for a math problem available on many internet websites, moreover there are many aids and helps for students in schools and some others provided by textbooks and book editors; inclusive many of them are complete courses reviewed by universities and prestigious educational institutions.

2 DESCRIPTION OF HIGH SCHOOL COURSES.

Algebra is the first course here the students learn the different methods to solve equations in order to find the unknown values. The course includes factoring and the understanding of algebraic equations; moreover the solution of simultaneous equations is also included in the course. Finally, the students are also introduced to work with logarithms. Traditionally, the students are prepared to solve a mathematical expression but they rarely are instructed to understand a real problem using these methods.

During this course, general and particular applications of algebraic rules are taught; but some of the most frequent errors during tests in classrooms is the fact that the students felt confused because they do not know which method or procedure must be used to solve each problem; and they often choose a wrong way. Traditionally the professor solves and explains in the blackboard any book problem. Although during algebra course the use of some dynamic presentation about the solution of some typical problems is recommended [1 & 2].

Trigonometry is the second course; here, every geometrical principle related with triangles, angles and trigonometric functions is taught. The course begins with the most famous trigonometric principle the Pythagoras theorem. The course also includes the solution of problems for hypothetic situations in two dimensional systems where trigonometry is involved; furthermore, methods to solve complex equations with trigonometric functions (sine, cosine, tangent etc.) are also included to be taught. Although triangles and geometrical forms are in everywhere all around us, for the students is complicated to imagine the possibilities and the potential useful of this course. Here visual presentations can also be helpful for students in order to show applications in the real world.

Statistics is a course where many analytical tools must be understood to solve problems which involve cases and data with a non representative behaviour. Here the students learn about grouping of the data and how to predict any behaviour using the previous information. In 70s, and 80s many statistical analysis might be done by the students using only a piece of paper and a calculator. Nowadays these analyses can be fast and easily done with the use of electronic calculation sheet software. Since the beginning of the 90s many professors have adopted Microsoft-Excel during their class time in order to show the students a quick and more efficient management of data. Moreover, computers have helped to analyze providing a graphical representation evidencing particular features of data populations.

Analytical Geometry is a course where the visual support is very important because algebraic equations must be solved to find geometry places which represent mathematical solutions. Here the use of any graphical software is recommended to show the students the representation of many equations; here the ratio between the grade of an equation and the corresponding graphical representation is taught, equations for lines, circles, parabolic, elliptical or hyperbolic forms are taught (second degree equations). The concepts of an independent and a depended variables and functions have a very important role. The use of polar and rectangular coordinate systems is also taught. During this course the use of any software to calculate and graph on computers provides a very important help for a visual point of view.

Pre-calculus and integral calculus are the latest courses; here the students learn to analyze the geometrical behaviour of the equations they solved in the previous courses; but with an infinitesimal point of view. Here the validation of the derivation and integration principles must be demonstrated graphically. Many concepts are abstract and difficult to be understood such as the calculation of slopes or areas under curves; reason why during these courses the visual and interactive aid is also required.
During all these courses the students just follow the professor instructions to solve the problems in the blackboard. Nevertheless graphical and visual materials for support are recommended for a better understanding.

3 USE OF SCIENTIFIC CALCULATORS AS AID FOR MATHEMATICAL COURSES

Textbooks and paper notes have been used to solve mathematical problems. During the 70s and 80s the most powerful tools were the calculators; nevertheless many scientific calculators had only a singled numerical displays and were very expensive, for the end of the 80s and during 90s the calculators becomes powered by new sophisticated chips and the graphical displays arise at the same time personal computers became more accessible for students, professionals and public [1 & 4].

This period represented a high jump for high school education and especially for engineering students making possible to watch in a small simple monochromatic display the graphing of an equation declared. Although some calculators became in mini-computers integrating the capacity to be programmed to execute a series of instructions, unfortunately these devices had a limited capacity for storing data and a complicated programming language that must be understood to work with.

Nowadays thanks to the improvement on the electronic and computational equipment is not absolutely necessary to have a scientific calculator, only a cell phone and download a digital application. The illustrations in figure (1) shows all the equipment and methodologies used during mathematical courses.

Mathematics is a wide world of knowledge and nowadays a good help for a better understanding can be provided to the student from many tutorials available on internet. There are many problems solved and theorems which have been demonstrated using iterative formats.

Many editors and authors have developed some complimentary materials for teaching support in addition to traditional textbooks aids. Here the students can see step by step the solution of many problems.

Nowadays is not absolutely necessary to go a library or a classroom for students to take any math lesson; if they do not understand the topic in the classroom, only an internet access is required to search any topic. Moreover there are many web-sites where students and professors can find problems solved in a free download or open access formats such as *.PDF or *.PPT. Nevertheless it must be careful due to it is necessary to make an appropriate and truly verification of the information [2].

Nowadays, the students use cell phones all time to be in contact; moreover the students in high schools are young boys who like technology, thus it is easy for them to learn the applications of these new devices. Frequently the students feel uncomfortable inside classrooms but they feel happy watching a small screen. The importance of the employment of new technologies to a wake and motivate students on math courses has been denotes by many authors [1,2,4,8].
4 USE OF GRAPHICAL SOFTWARE TO SOLVE MATHEMATICAL PROBLEMS.

Students of high schools are between 13 to 19 years old. They are teenagers; a complicated age for studying.

A change on the student’s performance was observed at the end of 90s when the computational resources were formally incorporated to the classrooms. This change can be appreciated on the graphics of figure (2); the change was done between 1994 and 1997. Then an increment almost in 10 percent on the students approved during the courses of Algebra, trigonometry, analytical geometry and statistics and an increment of almost 7 percentage in the students approved in pre-calculus and integral calculus courses. These latest courses remain be considered as the most difficult inclusive including the computational aids. The information shown in this figure was taken from the averaged results obtained of an entire generation of students from the high school # 9 of the Institute Polytechnic National in Mexico City. This information has been stored by teachers and authorities to evaluate the students’ progress. The difficulty of the tests applied to the students during every course is assumed as standard and certified; due to the institute is accredited by national and international institutions dedicated to evaluated and accredited scholarship programs as SEP in Mexico and ABET worldwide.

Nowadays a student can access to many virtual libraries or web sites on any place around the word to check and verify any information whatever. Thus the searching process for any topic has become easy. Students can do it directly from their cell phones, tables or laptops. A new world of knowledge is in our hand; nevertheless according with the averages of the students’ scores during the latest 10 years (2005-2015) has not been a notorious improvement on the students’ performance. This graphics shows a certain improvement on the high school students; nevertheless the concept of real improvement is not absolutely convincing for everybody.

The registers about the students’ performance when they arrive to universities has not either indicated an improvement on education quality. Thus something is happening during the change from high school to universities. The students seem to forget quicker than in older times; moreover when a test is applied to the students to be solve without any electronic help the scores are dramatically falling down.

Figure 2. Improvement of the students’ performance for the mathematic courses on high schools.
A set of 25 groups of 50 ex-students of the old high schools (now workers, professionals or students of universities between 20-45 years old) were contacted via e-mail to answer a brief test about the mathematical course they took many years ago with the purpose of evaluating the knowledge they received. The 50 students of every of the 25 groups correspond to every year from 1990 to 2015 and the test involves only 5 questions or problems per course taken; these questions and problems are considered as very easy to be solved and without the need of the use of any electronic device; nevertheless the ex-students performance was considerably minor; the percentage of approved students was less than a half as can be appreciated on figure (3). Here can be confirmed that pre-calculus and calculus remain as the most difficult courses. But inclusive in these courses the students of the 90s got the best notes.

![Ex student performance on the math test](image)

**Figure 3. Student's performance for the mathematic courses on initial courses on universities.**

They were interviewed to say their opinion about the new methodologies for teaching the mathematical courses. Many of them are fathers with sons in the high school level. They are agreed with the fact that visual aid is essential to understand many mathematical concepts; furthermore they are also agreeing that the inclusion of many internet web-sites with mathematical tasks have aided to the students to understand many mathematical lessons [7].

Many of the ex-students interviewed told that they liked so much to have had the possibility of any computational aid or support when they were students. They also add that everything seems to be easier today. But even with the help of computers it is still necessary to reinforce the knowledge because the students forgot quickly especially when they do not practice.

Mathematics require practicing because use the intelligent to solve problems; thus the need to participate solving task in classrooms is evident as any other engineering activity [3, 5 & 6]; mathematics require to be demonstrated and understood to build new knowledge from their basic principles.

The relationship between mathematics and all sciences is also evident especially with engineering; nowadays the computational helps provide a good option and support for many engineering topics related with mathematics; moreover the development of many computer simulators for engineering application were based on programming and the use of numerical methods [3, 5, & 6].

## 5 CONCLUSIONS

The solution time for many mathematical problems has been reduced and the understanding of many mathematical concepts has become easier and more accessible to the students.

Computers have contributed significantly to improve the teaching-learning process in mathematical courses in high schools.

Nevertheless the problem of remember math concepts and the capacity to solve problems remains after a not so short or a long period of time especially if the ex-student never practice again. To learn for to teach and to learn for a life is a different problem.
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REFERENCES


