Teaching Mathematics in a Different Connected World of the 21st Century:
Computer Simulations in Mathematics Education

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Abstract
Mathematics educators have been emphasizing the importance of integrating technology in schools in general, and in mathematical education in particular in ways that will promote learning, understanding and motivation to study mathematics. We believe that the school curriculum should be changed by adding up to date topics and teaching them applying technology.
In our presentation we will describe how we teach one topic accordingly: Area approximation under a given curve (for a desired accuracy), which we approach in a unique way, by using computer simulations and excel. So far using simulations is absent from the mathematical curriculum (in our country).
As a simple example we will describe The Monte Carlo simulation to area approximation and concentrate on the computation of the area of a unit circle.
Teaching this subject gives opportunity to introduce various websites for activities dealing with the number Pi for students in various levels. This can also be taught by e-learning (asynchronous or synchronous) and leads us one step forward towards teaching mathematics in a different connected world of the 21st century.

In the 21st century, more mathematics educators agree that an extensive use of computers, integration of technology in schools in general, and in mathematical education in particular is desirable. The use of technology has been found to improve students' attitudes towards learning (Schwartz, 2013). "There is a recognized need … of engagement-rich learning experiences that incorporate emerging technologies in pedagogically sound ways," (Henrickson and Doering, 2013). The NCTM standards (1989) have recommended this over 25 years ago.

In a previous paper presented at the 11th International Conference of The Mathematics Education into the 21st Century Project in South Africa we described (Hoffmann and Klein, 2011) two technology based courses which are taught to mathematics B.Ed. and M.Ed. students in a teacher training college in which the use of computer technology enables us to integrate into the school curriculum topics which are ordinarily absent from the regular school program in our country. In that paper we mentioned the topics taught in the courses and focused on one subject, mainly:
Finding roots of various kinds of equations which have no analytic solving formulas (exponential, trigonometric or polynomial of a degree greater than 4) in a unique way, by writing first and second order numerical programs using excel spreadsheets and GeoGebra for illustration.
In this presentation we will describe one method of Area approximation under a given curve (for a desired accuracy), which we approach in a unique way, by teaching computer simulations using excel.

**Simulation** is the imitation of a real-world process or system over time. It is used in many contexts when the real system cannot be engaged, because it may not be accessible, it may be expensive, dangerous, or it may simply not exist.

A computer simulation is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. By changing variables in the simulation, predictions may be made about the behaviour of the system. It is a tool to virtually investigate the behaviour of the system under study.

**Mathematical simulation** attempts to find analytical solutions, enabling the prediction of the behaviour of the system from a set of parameters and initial conditions. Computer simulation is often used in addition to, or substitution for, modeling systems for which simple closed form analytic solutions are not possible (Banks, Carson, Nelson & Nicol, 2001).

So far using simulations is absent from the mathematical curriculum (in our country).

In our presentation we will show how modern day technology enables combining this subject matter in the school curriculum. As a simple example we will describe The Monte Carlo simulation to area approximation and concentrate on the computation of the area of a unit circle, which leads to the approximation of Pi (Hoffmann, 2000).

The term “Monte Carlo method” is a general one. It refers to numerical methods based on probabilistic algorithms, or randomized algorithms, which use elementary statistical methods, allowing rapid approximate solutions to problems whose computational solutions are not known or are inefficient (Harel, 1992). Monte Carlo methods are used in various fields of computational science - economics, statistics, nuclear physics, chemistry, biology, mathematics etc.

We will present the method, the algorithm written by the students, the numerical output received using the Excel spreadsheet, in combination with a graphic presentation and a visual presentation clarifying the process as a whole.

If time allows, we shall also present the simulation of the “Buffon’s needle” (Breuer & Zwas, 1993), and simulations of basic probability.

It should be mentioned that in all classes where those topics were taught in a face to face manner or in distant learning, it met with great enthusiasm and interest by the students. These subjects introduce students to a chapter belonging to modern applied mathematics, and create opportunities to discuss important mathematical concepts (in various levels) such as: the concept of area, the concept of probability, the use of simulation, approximations, etc. This allows presenting students with yet another facet of computer use in mathematics, and leads students to experience mathematics studies in a new and different way.
In addition, teaching this subject gives opportunity to introduce the use of Internet as a source of information and data base. For example - the students find rich data in various websites for activities dealing with the number Pi for students of various levels.

We believe that using 21st century tools as computer simulations, a variety of websites and distant learning- **asynchronous or synchronous Internet communication technology** will be one step towards teaching mathematics in a different connected world of the 21st century.

**REFERENCES**


http://blogs.kqed.org/mindshift/2013/08/rand-study-shows-blended-learning-works