Project Work Using Mathematical MacTutor

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Abstract: The Mathematical MacTutor is a powerful didactical sofware designed by Edmund Robertson and John O   onnor at the University of St Andrews. The program provides an easy connection between mathematical experience, mathematical theory, and the history of mathematics. The user can explore the data of mathematical problem, make a hypothesis and then find evidence to prove the assumption.

The aim of the paper is to present the way Mathematical MacTutor has been used at the University of St Andrews, Scotland, with first and second year students, and at the University of Miskolc, Hungary, with first year mechanical engineering students.

Keywords: MacTutor, project teaching, individual learning

About Mathematical MacTutor

The Mathematical MacTutor system [1] consists of more than 100 HyperCard stacks amounting to about 18 Mb and about 2000 cards. It runs on any of the range of Apple Macintosh computers, but not on PC's.

It is being used in many universities and colleges, both in the UK and abroad and also in many secondary schools. It won the 1992 Partnership Trust prize for innovation in Mathematics teaching.

It has continued to be developed since and won the prize for the best Mathematical Software in the European Software Awards for 1994.

In August 1995, it won an Undergraduate Computational Engineering and Science Award sponsored by the Department of Energy of the United States of America. You can see the presentation which won this award at: http://www-groups.dcs.st-and.ac.uk/~history/Miscellaneous/darcy.html .

MacTutor covers a wide range of mathematical topics, though its contents have been biased by the interests and enthusiasms of its authors. They have concentrated on areas where they think that the computer, and particularly the superb graphics capabilities of the Apple Macintosh, can give insights not available in other ways. Thus, apart from the Calculus topics that one would expect to find in any mathematical software, MacTutor is particularly strong in Geometry, Algebra (and in particular, Group Theory), Graph Theory, Number Theory and the History of Mathematics. It has some interesting stacks on Statistics, Matrices and Complex Analysis.

MacTutor History of Mathematics archive on web

It was developed initially as part of the Mathematical MacTutor system for learning and experimenting with mathematics. The archive contains the biographies of more than 1300 mathematicians. You can access them from a selection of Alphabetical or Chronological Biographical Indexes. It contains some articles on the development of mathematical ideas cross-referenced to the biographies. You can access these using the History Topics Index.

There is a collection of more than 60 articles on Famous Curves which have been extensively studied by mathematicians, giving their history as well as pictures of the curves and various curves (evolutes, inverses, caustics etc.) which are associated with them. If your browser is capable of handling JAVA, you have the option of experimenting with these curves in an interactive way.

The interested people may find more about the system, and especially about the History stacks at http://www-groups.dcs.st-and.ac.uk/~history/.

The History in MacTutor, and capabilities of the system

The History of Mathematics on the World Wide Web is one part of the system. As part of the MacTutor system it is integrated into the other stacks, so that one can cross-reference the biographies from the mathematical stacks and can go from the biographies of mathematicians to stacks which are connected with the mathematics that these people were responsible for.

MacTutor is not designed to replace any of the conventional modes of teaching, but to supplement them with a system that will reinforce the existing course work. Innovative features of the system provide the opportunity to experiment in mathematics with the chores of lengthy calculation and formal analysis removed.

The fact that no knowledge of programming is required means that the mathematical ideas are neither lost nor obscured by other difficulties. MacTutor is a laboratory for conducting mathematical experiments.

Projects using the Mathematical MacTutor, their role in teaching

In St Andrews the undergraduate teaching of different Mathematics courses are organized in: Lectures 5 hours, Practicals 1 hour and Tutorials 1 hour per week in the first two levels [2].

The MacTutor project work is a part of Practicals and Tutorials, and each semester the student has to access 3 such projects. The 20% of the assessment mark is from continuous assessment during the semester. The remainder is from a 2 hour exam at the end of the semester.

There are 3 projects for most modules. The first year ones are in the form of "worksheets" which students fill in and hand back. We introduce the first year projects in the microlab and supervise the session in the following week. Students are expected to work on them for 3 hours over three weeks. For second year modules, the students write a report and hand that in after (supposedly) working on it for three hours. We don't introduce the second year projects in the lab since students are familiar with the hardware and software by then.

First year students are given worksheets to complete. These lead them through various areas of mathematics using the facilities of the computer to explore phenomena, which they are then asked to find mathematical explanation for. Second year students work on the computer more freely. The projects set for them are designed to be more open-ended and the students prepare reports on what they have done.

The projects for the first year students are designed to occupy the students for three hours at the rate of an hour per week in the MacIntosh laboratory. In the first hour the class was introduced to the project, shown the facilities in the MacTutor available for working on it and given some of the mathematical background of it. The following two weeks were available for students to work on it, eother on their own or in groups and at the end of this time they wrote a short report about what they had done and what they had learnt.

Here is the list of the first year projects:

        A   Plotting functions
        B   Polar coordinates
        C   Envelopes
        D   Numerical integration
        E   Pascal   triangle and mathematical induction
        F   Minimising distances
        G   Graph theory

| H | Iterating fuctions |
| I | Differential equations |

The second year projects cover similarly the taught material.

Based on the experience in using this projects with students while visiting St Andrews University, I have introduced similar projects for students in the University of Miskolc since 1996 [3]. The first and second year Mechanical and Mining Engineering students involved with the MacTutor projects were using the original English language version of Mathematical MacTutor. In order the avoid language difficulties, we created with the authors of MacTutor a translator program, which was used to finish a smaller Hungarian version of the system. Students with poor English can now use for the first this version, to understand how the software works and then to be able to use the whole. In the past years I completed the list with projects destinated to engineering students especially.

The smaller Hungarian version contains the following 4 packages and 22 stacks:

Calculus Package	Statistics package	Matrices	Complex numbers
Graph plotter	Buffon needle	Matrix transforms	Complex functions
3D graph plotter	Capture-recapture	Vector demos	Complex roots
Differentiation	Data display	Gauss elimination	Conformal mapping
Sequences	Discrete distributions		Complex calculator
Series	Normal Distributions		
Applications of Calculus	Probabilty		
Taylor series	Regression		
Differential Equations			

The projects and MacTutor have been used with pre-university course students and a small group of talented secondary school pupils as well.
I have to mention that the only obstacle in the wider use of the MacTutor projects is the reduced number of MacIntosh computers available at the University of Miskolc, even if we consider the computers belonging to other departements of the university.

Education and the use of the software

The software was studied and widely used by the members of the Mathematics Group, mathematically enabled secondary school and first year students. This group is in function since 1992, and it is involving each year 15-20 of the students of the local F   des and Zrinyi Grammar Schools. The group's work is co-ordinated by the author, as one of the educational project-activities of the Institute of Mathematics of the University of Miskolc, designed to develop special mathematical abilities for students of the age between pre-university education and research.

Educational principle, strategies and methods

The main educational principle of the project activity an extension of "learning by doing" to a new concept of " deep-understanding by explaining".

The most important strategies the students learn during the project are:

- Mathematical reasoning by emphasizing that any problem can be solved in many ways.

- Find and apply the most appropriate solution intuitively.
- Apply problem solving technique to real world situations.
- Develop creative thinking skills, cooperative learning technique.
- Communication skills, through written and oral presentations, resulting in logically- developed solutions, gaining self-confidence for both academics and careers.

The methods they learn are based on the content of the cover-page of the P ya's book "How to solve it", and can be summarized as:

1. Understanding the problem
2. Making up a plan of the solution
3. Implementing the plan of the solution, getting the answer
4. Checking and explaining the results.

During the activity of the group the students read, write and discuss about mathematics, they choose some areas of elementary mathematics, read books and articles about it, and prepare a presentation for the rest of the group. For this presentation they use Mathematical MacTutor, the Geometer's Sketchpad [4] and other mathematical software. The result of their investigation is not only an oral presentation, they learn to use Scientific Word to make up a report in written form as well [5].

References

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Authors :

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The software is available for sale as well, but a MacTutor demo (as a binary self-extracting archive, about 600K) can be obtained by anonymous ftp from:
`gregory.dcs.st-andrews.ac.uk` in the sub-directory /pub

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