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IT in Mathematics : An Example

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1. IT in Education:

Computers have been around now for about half a century. It has penetrated almost all aspects of life. It has been used in research since its early years. However its efficient use in education has taken momentum only in the recent years. The introduction of pre-computer age technology , such as films, radio, TV and audio visual aids had touched education only slightly. The vast majority of schools, universities and other educational institutions continued to use traditional methods before the introduction of computers and computer networks . With the wide spread of the connection to word wide web, cheap personal computers, vast amount of disk space available, availability of CD-Rom Drives, possibility of installation of local area networks and the alike are all lending themselves to the help of schools , universities, other training and educational institutions as well as the possibility of education at home by the student himself using his PC directly or as a mean for connection to the internet. The amount of courseworks , educational materials, software and other aids for learning available on the internet is increasing rapidly(1). However the web is not yet suitable for learning. Learning is in general still costly, slow and contains a lot of gaps. (2)

A lot of research has taken place to use the new technology in education. What seems happening is that we are encountering the begining of a new era of education system which changes most of traditional habits, practise and system of education.

2. AI in Education

Artificial Intelligence (AI) is one field which is entering education slowly and steadily. Since the traditional educational system had accumulate a vast amount of intelligence as well as utilization of human intelligence of the instructor who is an important constituent of the system , the newly imerging system is utilizing the field of AI in a growing manner.

The earliest applications of AI in education developed intelligent tutoring systems (ITS). It is the first (and still foremost) application of AI to education. The heart of an ITS is its expert system. The expert system embeds sufficient knowledge of a particular topic area to provide “ideal” answers to questions, correct not only in the final result but in each of the smaller intermediate reasoning steps. The expert system thus allows the ITS to demonstrate or model a correct way of solving the problem. Often, like any system, viewed as a software product, is likely to have a brief life-

span and will directly impact few learners. Students using the system may use their ability to generate highly detailed feedback about solving problems. It is important to note that not all software fits into classrooms so easily.

In the last several years, applications of AI in education have diversified ;If we focus our attention on mathematics ; While many early ITS focused mainly on simple topics in high school mathematics, recently ITS have been developed for more advanced topics in mathematics (3). GIL has been experimentally compared to the original version of the tutor, which includes no graphical front end. The results showed, perhaps not surprisingly, that the graphical interface contributed significantly to improvements in student outcomes.

Construction not instruction. Students learn most effectively by constructing their own knowledge, not by being told through lecture, nor through organized drill-and-practice.

Educational technology is now largely limited to the few methods of learning . However, in addition to drill-and-practice and inquiry, there are many other ways to learn. Some new methods are just beginning to be examined in the educational technology literature. Tools for visualization exploit the computers ability to render complex patterns succinctly in graphical representations. Visualization often permits learners and professionals to get broad pictures of data, to generate intuitions, and to suggest hypotheses for further testing. In some cases visualization may even substitute for symbolic reasoning and proof, not merely supplement it (4). In these areas, then, visualization tools are providing new perceptual methods to more simply accomplish activities that, previously, required much subtle symbolic reasoning. But in other cases, visualization technologies are opening up completely new fields of study and defining new goals for curricula as well as providing new methods of learning.

New teaching practices and professional standards shall become a must. If teachers are to move from lecture and drill-and-practice methods of teaching to new methods like inquiry- or project-based learning, general standards will need to be established for these new methods, along with rich collections of specific teaching practices, strategies, and tactics. New goals and methods for teaching and learning imply extensive changes in teacher education and in the content and practices of schools of education(5).

3. IT in Mathematics

Programming languages started its early ages as calculators with the possibilities of some programming. That gave the ability of introduction of most mathematical functions, and many mathematical algorithms as essential parts of most of the programming languages main structures. In the last decade , new programming languages or mathematical tools such as Mathcad, Matlab and Mathematica were introduces. These new tools offers themselves not only as means of solving problems but as well as teaching tools for teaching the students new mathematical ideas and concepts.

However, the use of technology in learning is often controversial and not favoured by all students mainly when the interface to such system is not user friendly.

Students today learn better using the new technologies that can provide a dynamic representation of information and concepts. In teaching mathematics, considerable effort continues to push forward the development of user-friendly systems, important to a deeper understanding of mathematical concepts in undergraduate students.(6.7.8)

A combination of mathematics, computer graphics, and communications technology is required to give the students a mathematical and technological experience that is a more dynamic way of learning.

Technology could significantly enhance the effectiveness and quality of teaching and learning by providing more independent learning resources and thus more flexible learning options for its diverse student body; and maximizing the efficiency and effectiveness of its communication with and between students.

Educators need a high level of computer literacy and skills to provide and maintain a domain of interactive CD-ROM and linked Internet services such as the WWW and multimedia.

Many students feel that traditional mathematics subjects lack application to real situations that are meaningful and relevant to their own ideas. Indeed the on-line teaching of mathematics can inscribe mathematical concepts as part of the students own experience, improving their overall understanding, logical thought processes, communication skills, confidence and the enjoyment in learning mathematics.

Students use software tools such as Maple or Mathematica, to test mathematical ideas such as the new methods in calculus and at the same time develop an awareness of the wider learning arena provided by access to the Internet.

Kaput (6) has suggested that the mathematical thinking ability to recognize translations from one representation of a function to another, can be assisted by the use of computers. The use of Maple or Mathematica in combination with the WEB, can develop new strategies and deeper understanding of the calculus concept.

1. students found the computer-based calculus interesting and enjoyable;
2. the windows version of Mathcad was easy to use;
- 3.the use of Mathcad improved the learning of calculus;
4. computer labs improve students perception of their calculus skills.

There should be more contact between the university and high school maths teachers if the use of technology in teaching is to be a success.

We should also stress here that using the technology does not imply giving up some traditional teaching/learning tools which have already proved effective for years.

3. Engineering Mathematics and IT

Engineering Mathematics is characterized by heavy orientation towards applications. Problems, examples, and exercises are of practical nature and could be directed towards the specific engineering discipline under consideration, eg. mechanical, electrical, civil or other engineering branches.

However there is no boundaries between normal undergraduate mathematics and the engineering mathematics. It is the way of dealing with matters that is the required and not the titles.

We must be aware of the side effects which eventually will result from the extensive use of the new technology.

It is not an easy job to make an average student understand the concepts and imagine the behaviors of mathematical equations without extensive effort both by the lecturer and by the student himself via solution of large number of exercises. Traditional methods of teaching basic mathematics as well university level mathematics has been based on derivation , proof of theorems, solution of examples, tutorial classes and solution by the student a lot of homework problems.

It has been found that computers can help in the better understanding of engineering mathematics by students. The following are only some directions where computers can offer a good help:

(1)Three dimensional objects are usually very difficult to imagine. Computer 3D facilities can be very helpful.

(2)When time is the independent variable and motion is involved, the imagination of the behavior becomes quite difficult. Here again computers can offer a lot through animation facilities and other means.

(3)When numerical solution of a large number of algebraic equations is involved, numerical solution of ordinary differential equations or partial differential equations, there is no easy way of understanding results and techniques except by high speed calculations and programming which the computers can offer easily.

The above three directions are only examples for the use of computers that can make understanding of mathematics easy. There are many more others.

In most electrical engineering departments for instance, boundary value problems, complex analysis and conformal mapping are considered as part of a course in advanced engineering mathematics. You can find now some software available for Modeling , Numerical Analysis ,Numerical Partial Differential Equations, Advanced Differential Equations, Complex Variables .Ordinary Differential Equations, Probability and Statistics

5.Mathemtics Education on the Web

There are now available on the world wide web a large amount of software which were designed intentionally for the purpose of aiding education of arithmetic, plane geometry, solid geometry, trigonometry, algebra, calculus, statistics as well as some advanced mathematics

Just an example , in one program that solves the Wave equation which is encountered in all kind of physical oscillation problems, e.g. a string of a violine, water waves, electro-magnetic waves...It serves as a demonstration for a linear scalar wave equation. We can observe phenomena like wave addition and canceling. Since we are solving the linear wave equation, the amplitudes have to be small. At the left end of the string is fixed (boundary condition) and right we enforce a horizontal solution. (11)

Appendix (1) gives some homepages related to this topic and software in relation.

Appendix (2) shows a list of web sites related to Mathematics Education on the web.

6. Project Oriented Mathematics Course

Over the last six years, computer oriented projects were introduced while teaching the course of Engineering Analysis III at the department of electrical engineering of Jordan University. Individual students were encouraged to solve a small problem on the computer. The allocation of the project used to be a result of offering a list of proposed problems, classroom discussions and private discussions with interested students.

Ideas about the nature of the program, language to be used, goal and scope were hinted to the student. However the whole experiment was optional and students are normally encouraged to participate in it by suitable mark incentives. Usually 35-70% of the whole class join in the experiment.

The projects submitted vary from simple single case study problem to a moderately complicated program. Some students who became so much interested were eventually stopped at certain stage so that no harm is reflected on their overall performance in their study. The languages usually used vary according to the student's wish and mastery, ranging from Qbasic, Visual basic, C++, Visual C, Pascal, Matlab, Mathematica or Excel.

Among the problems solved were :

Fourier Series of linear or piecewise linear functions or of given expressions

Solution of One dimensional Wave equation by various methods.

Solution of Membrane Vibration with different initial displacements.

Solution of the Heat equation with various boundary conditions.

Complex Numbers Arithmetic and Calculations

Conformal Mapping

Numerical Solution of specific type of Partial Differential Equations

General Numerical solution of Partial Differential Equation.

One specific example which showed specific interest and were tried by students in quite different ways was the solution of the wave equation using D'Alembert solution by showing forward moving component of the wave and the backward moving component. This problem was tried by different students by quite a number of different ways and some of them were quite interesting so that they were used subsequently in explaining the whole idea of the solution method for the following batch of students. Some students used animation in a way which showed quite a good understanding of the nature of the problem as well as competence in programming.

7. Computer Programming Aiding Mathematics Course

The above example given in relation to D'Alembert solution was a good example for programs which can be used subsequently as an aiding tool through teaching of the subject.

Use of ready made packages available through the internet or through purchasing are other possibilities.

Another way for getting such tools is through well prepared and well defined final year projects. Here are two examples for such projects.

Example 1: Conformal Mapping Tutor:

This program consisted of two different modules: The first one is mathematical and the second one is for application of the method in electric circuits.

The mathematical module accepts different mathematical forms of well known complex functions with the various parameters to be fed by the user himself. Any shape or region may be reflected under the chosen mapping to the new shape with coordinates reflection on the new plane.

An example of the output for specific problem is shown in figure (1)

The electric circuit module contains a user friendly interface for circuit diagram entering and then the program shows the locus of the input impedance (or admittance) when one element in the circuit is varied continuously.

Example 2: Transmission Line Tutor.

In this project the students tried to touch nearly all aspects related to transmission line encountered by the student through his undergraduate study. Mathematical formulation, wave propagation, power line methods, HF communications lines, and other detailed encountered were all dealt with.

Figure (2) shows the equipotential around a transmission line. Figure (3) shows some of the waves which the program produces for specific data. The program contains a suitable user friendly interface.

8. Discussion and Conclusions

The use of IT in education in general is gaining a lot of momentum. It is expected that it is going to show a tremendous effect on the shape of education, means used and even courses contents in various stages and fields of education.

Use of IT in mathematics should be strongly encouraged at university level. Individual students projects are valuable means in students education as well as their benefits for subsequent developments of the courses

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11. P.J. Larcombe, *Engineering Mathematics: The crisis continues*. *Engineering Science and Education Journal*, Dec 1998 pp273-281

10 Appendix (1)

UK Matlab information (Cambridge Control Ltd)

MathWorks Home Page

MathWorks Educational Home Page

Matlab at Indiana University (contains links to a range of Matlab resources)

MathTools Ltd (developing tools for use with Matlab, such as a Matlab to C++ compiler)

MATLAB Toolboxes from The University of Birmingham

Newsgroup: comp.soft-sys.matlab

Differential Equations: radioactive decay; solving a separable equation via symbolic integration and series; modeling one-dimensional diffusion (diffeqs.mcd, Mathcad 4.0, 23 kb)

Complex Variables: conformal linear and nonlinear mappings; evaluating complex contour integrals; visualizing a complex function (cmplxct.mcd , Mathcad 4.0, 24 kb)

Geometric Bounding Toolbox (GBT) for MATLAB

complimentary software to accompany the textbook: *COMPLEX ANALYSIS*: Maple Worksheets Mathematica Notebooks Prof. John H. Mathews , Department of Mathematics California State University Fullerton, Fullerton, CA 92634 E-mail: mathews@fullerton.edu and Prof. Russell W. Howell Mathematics & Computer

Science Dept. Westmont College Santa Barbara, CA 93108 E-mail:howell@westmont.edu

COMPLEX ANALYSIS: for Mathematics & Engineering

Jones and Bartlett Publishers, Inc.

Motivation in Computerised Mathematics” at Griffith University and “Developing an Assessment Program Incorporating Graphics Calculators” at Murdoch University

Mathematics Archives in the Internet archives.math.utk.edu.

The use of on-line hypermedia on the World Wide Web in the teaching of university and high school mathematics.techniques to balancing distance teaching and on-campus teaching methods. In the Harvard University, Core Calculus Consortium

The Calculus & Mathematica Distance Education Program (C&M DEP) at the University of Illinois at Urbana-Champaign and The Ohio State University(7)

11 Appendix (2)

<http://www.staff.ncl.ac.uk/john.appleby/diagpage/diagindx.htm>

<http://www.icbl.hw.ac.uk/marble/maths/public/assessment.html>

<http://www.demon.co.uk:80/qmark/>

<http://java.cms.livjm.ac.uk/treefrog/tests.htm>

<http://sword.gcal.ac.uk/calmat/calmat3.html>

<http://www.liv.ac.uk/ctichem/c3cq.html>

<http://cba.scit.wlv.ac.uk/about.htm>

<http://calmaeth.maths.uwa.edu.au>

<http://metric.ma.ic.ac.uk/came/>

<http://www.nag.co.uk/symbolic/AX.html>

<http://www.derive.com/drvset.htm>

<http://www.tech.plym.ac.uk/maths/DERIVEHM/DEVCONT.HTML>

<http://www.can.nl/SystemsOverview/General/Derive/grandtour/node23.html>

<http://www-groups.dcs.st-and.ac.uk/~gap/>

<http://www.macsyma.com/>

<http://www.maths.usyd.edu.au:8000/comp/magma/Overview.html>

<http://www.adeptscience.co.uk/as/products/mathsim/maplehttp://www.maplesoft.com/maplevr5.html>

http://www.maplesoft.com/alpha_index/documents/betaindex.html

<http://www.indiana.edu/~statmath/math/maple/>

<http://web.mit.edu/afs/athena.mit.edu/software/maple/www/home.html>

<http://www.adeptscience.co.uk/as/products/mathsim/maple5/html/reporter.html>

<http://www.cecm.sfu.ca/projects/OMP/omp-index.html>

<http://www.ma.umist.ac.uk/kd/ednet/maths/maple/readme.html>

http://www2.ncsu.edu/eos/info/maple_info/www/
[href="http://www.adeptscience.co.uk/as/products/mathsim/mathcad](http://www.adeptscience.co.uk/as/products/mathsim/mathcad)
<http://www.mathsoft.com/>
<http://www.mathsoft.com/eduindex.html>
<http://www.mathsoft.com/mathcad/70dir/treasury/>
<http://www.intl.mathcad.com/>
<http://meerkat.adeptscience.co.uk/listarchive.nsf>
<http://www.umanitoba.ca/IMP/IMP2.html>
<http://www.milohedge.com/products/mathlive/mathlive.html>
<http://www.wri.com/mathsource/index.html>
<http://www.wolfram.com>
<http://www.telospub.com/journal/MIER/index.html>
<http://www.ma.umist.ac.uk/kd/ednet/math/mathematica/readme.html>
<http://www-cm.math.uiuc.edu/>
<http://www.keele.ac.uk/depts/ma/mathtech/>
<http://www.artlandia.com/>
<http://www.maplesoft.com/Products/MathView/mathview.html>
<http://www.maplesoft.com/CyberMath/>
<http://www.camcontrol.co.uk/matlab.htm>
<http://www.mathworks.com/>
<http://education.mathworks.com/>
<http://www.indiana.edu/~statmath/math/matlab/>
<http://www.mathtools.com>
<http://sun1.bham.ac.uk/veressm/matlab.html>
<http://www.mupad.de/>
<http://www.rrz.uni-koeln.de/REDUCE/http://www-rocq.inria.fr/scilab/>
<http://www.damtp.cam.ac.uk/icrd/CC/index.html>
<http://www.maths.gcal.ac.uk/calmat>
<http://www.bham.ac.uk/mathwise>
<http://metric.ma.ic.ac.uk/>
<http://caliban.leeds.ac.uk/>
<http://www.mathware.com/html/cyclone.html>
http://members.xoom.com/FeYiLai/dr_geo/doctor_geo.html

<http://www.wkap.nl/kaphtml.htm/ENMACDROM>
http://stork.ukc.ac.uk/computer_science/EMT/
<http://www.maplesoft.com/Products/expressionist/expressionist.html>
<http://www.umist.ac.uk/ITTI/>
<http://www.keypress.com/product-info/sketchpad3.html>
<http://www.anglia.co.uk/education/mathsnets/graphicalcs.html>
<http://www.cafe.net/peda/http://www.awl-ile.com/math/intdifequ/index.html>
<http://www.mathtype.com/>
<http://www.awl-ile.com/math/modellus/index.html>
<http://www.anglia.co.uk/education/mathsnets/omnigraph.html>
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<http://scinotebook.tcisoft.com/scinotebook/default.htm>
<http://www.thomson.com/tcisoft/products/swver25.html>
<http://www.thomson.com/tcisoft/products/swp2v25.html>
<http://www.mathsoft.com/studyworkshttp://www.alphaWorks.ibm.com/formula/techexplorer>
<http://www.ucalc.com>
<http://www.adeptsience.co.uk/as/products/mathsim/vissim>
<http://www.bham.ac.uk/ctimath/copyrt.htm>

Figure(1)

Figure(2)

Figure(3)