

Computers in Science Education

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ABSTRACT

Science education must be on top of the agenda for all the developing countries. The main hurdle is lack of good teachers. Taking appropriate help of computers in teaching learning process may enhance the effectivity of the existing teachers. The laboratory is most important parameter in science education. Virtual laboratories can help students to revise the work done in physical / real laboratory. e-learning will also be affordable in couple of years. Appropriate inter-active content will have to be developed. The paper deals with these areas. Some modules demonstrate following ideas:

1. Clearing Concepts
2. Discovery Learning
3. Virtual Laboratory
4. Problem Solving
5. Validation of Formulas

Key words: E-learning, CBT, Virtual Laboratory, Discovery learning, Problem solving.

INTRODUCTION

1st computer was put to use in 1943. But it took almost 40 years to get the computers on the desks. The microprocessors and desktop computers have changed the way we work. Microprocessors have automated almost all processes. This has brought speed and accuracy and has replaced workers to a large extent. The scale of manufacturing has changed and has brought down devastating effect on the developing countries. Industries of these countries had shown steady growth. But the globalization and opening of economy had a catastrophic effect. And only those industries, which maintain the quality & efficiency, will survive. Computers are invading many fields and consequently millions of people will be rendered jobless and will have to be re-trained to take up new jobs.

The obsolescence with regard to technology is very fast. And consequently skill obsolescence is also rapid. This engenders need to learn new skills. The learning process has to be life long. The importance of Teaching Learning Process (TLP) will be more and more. In the near future the web will be most powerful and widely used means for the self-learning. As on the date developing countries don't have infrastructure to launch the web-based learning. But all the teachers should concentrate on preparation of the appropriate material for the web. Consequently, importance of a good teacher will enhance. All the teachers should take a note of this and undertake efforts to improve their skills in this direction. The computer shall be the best tool in the hands of a teacher as explained below:

AREAS OF USE OF COMPUTER

Clearing Concepts

Computer along with multimedia is a very powerful Audio-Visual Medium. It can be used to clear the concepts. The examples are curve tracing of mathematical functions, modulation and demodulation in signal transmission, loci in mechanics, mechanisms in theory of machines, various processes in Chemical Engineering. The multimedia modules can be made interactive so the interest of students is kept at enhanced level and hence students will not see but observe. It may be noted that the retention is also much higher through visuals.

Discovery Learning

Teacher can design modules so that students can discover the relation rather than being told by the teacher e.g. simple pendulum has parameters namely Length (L), Diameter (Ds) and Mass (ms) of the string, Diameter (Db) and Mass (mb) of the bob & the gravitational acceleration (g). Student can go on changing one parameter at a time and observe the period of oscillation and hence finally he may conclude on the relation: $T=f(L, Ds, ms, Db, mb)$.

DISCOVERY LEARNING IS PERMANENT AND LEADS TO THOROUGH UNDERSTANDING OF THE PHENOMENON.

Virtual Laboratory (V.L.)

The physical or real laboratories have some limitations. We have normally just one set of equipment or samples. The equipment has fixed set of parameters. The students know these parameters. The students get marks, only if correct answers of these parameters are obtained. Hence the students preserve the readings for generations. The best student is hence de-motivated to do such experiment and nothing worthwhile is achieved by this exercise. It is proposed to acquaint the students with the physical set of the equipment and then switch over to virtual laboratory on computer screen. Here the parameters are not known to the student's apriori and hence the students are motivated to perform the experiment. The virtual laboratory shows no moods of the experimental set-ups. The VL always performs with precision.

Physical laboratory samples have some peculiarities and will not always show up all the important characteristics. Some students just remember the sample number and by heart the attributes. The set of physical sample can be augmented by slide collection in computer. The students can observe these samples, in the form of slides, at different angles by rotation of the samples. These will have all the correct attributes of the samples. In fact in diamond collection in geology laboratory, we can have Kohinoor diamond to arouse the interest amongst students.

Problem solving

Up to sixties, science students used slide rule. In eighties the students started using calculators, then the programmable calculators arrived. Now is the time to use computers. The computers will eliminate the drudgery of numerical and symbolic

manipulations and consequently will lead to better understanding of the subject. There many good soft-wares viz. Matlab, Mathcad, Maple, TK4-solver are available.

Validation of Formulas

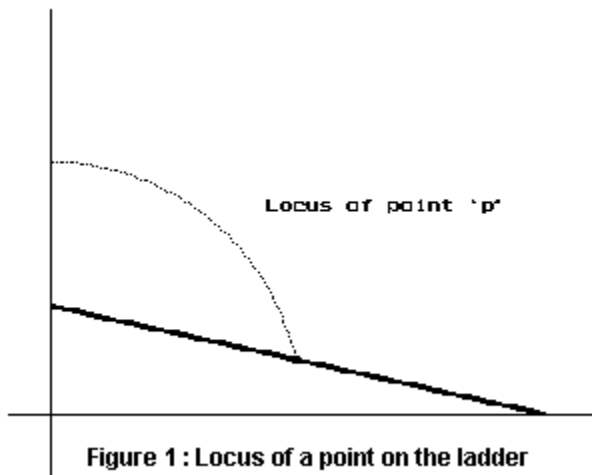
Computer may be used as an effective tool to validate mathematical formulas.

Computer Demonstrations- Senior author with help of others has prepared about hundred demonstration modules to generate interest in the topic and to illustrate the points.

a) Clearing Concepts

This is explained by following:

1) *Ladder Problem*- A ladder is leaning against wall. It starts slipping, contact between wall and floor is maintained.

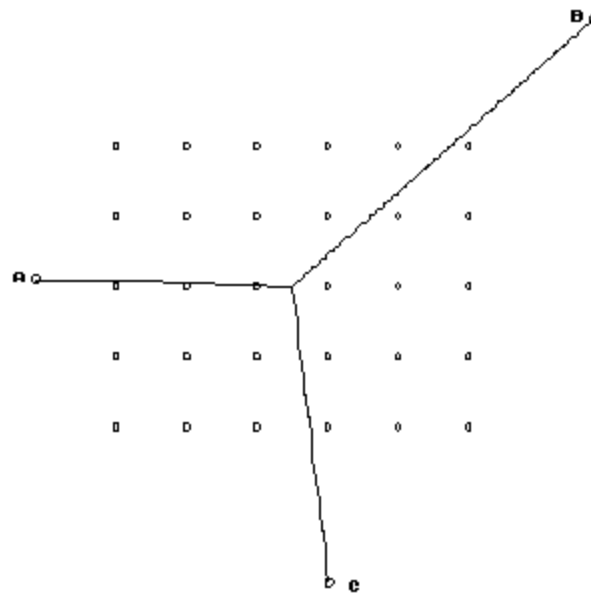


It is required to obtain locus of a point on the ladder. Almost everybody feels that the locus will be hyperbola. On solving the problem mathematically, one gets ellipse and hence there is a confusion in the minds of students.

This is best cleared by this demo, which shows the plot of locus point by point. And any point on the ladder may be chosen to view the demo. Refer Fig.1

2) *Optimization problem*-The optimization problem is explained with the help Steiner's problem by three methods. The problem is as follows: there are three cities A, B and C. These cities are to be connected by road system, so that total length of road system is minimum.

Exhaustive Search method- the starting solution is taken as A, B and C connected by straight roads. The feasible region is marked with a grid. The graphical demo in Fig.2 shows a grid. For each point of the grid roads are connected, length is calculated and if the trial is less than previous solution, previous value is replaced. The size and grid spacing is halved at the end of each cycle. Few cycles lead to acceptable solution. The demo nicely explains the exhaustive search method. In the end objective function contours are plotted to further clarify the nature of the variation of objective function.



**Figure 2: Steiner's Problem
(Exhaustive Search Method)**

Steepest Descent Method- This demo in Fig.3 shows as to how the steepest descent or ascent method works. Steiner's problem is taken again. The objective function contours are drawn. A starting point is chosen at random. A step is chosen and steepest descent direction is found at this point. A step is executed in this direction to get second point. The procedure is continued till one reaches the optimum point.

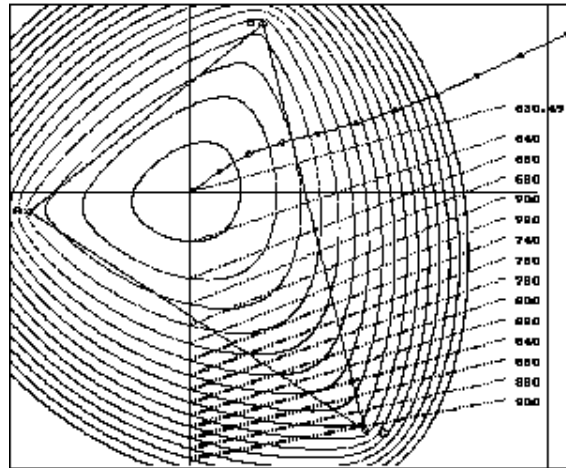


Figure 3: Steiner's Problem
(Steepest Descent Method)

Uni-variate Method- This method is similar to Steepest Descent Method. Here one moves along x & y direction alternately to reach to the minimum. Refer Fig.3(a).

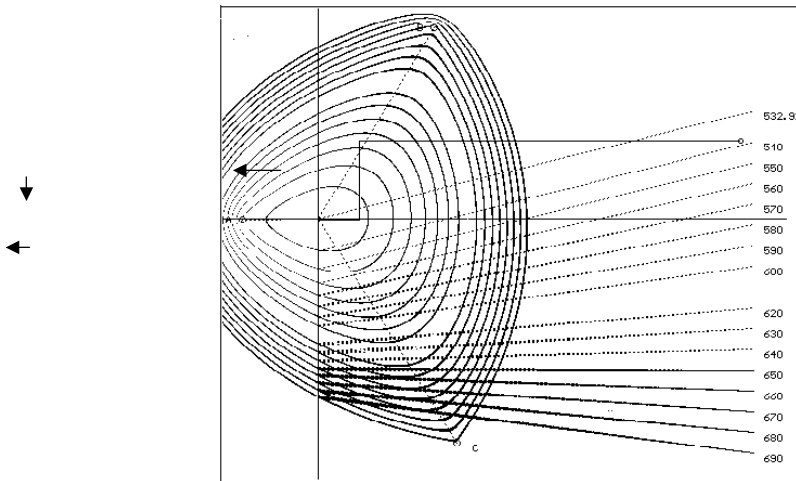


Figure 3(a) Steiner's Problem by Univariate method

b) Complicated Diagrams And Constructions - This point is best explained by following two demos:

1) *Rangoli*- Rangoli is traditional Indian art with quite complicated patterns guided by grids of equidistant points. The speed of the demo can be controlled at will. Figure-4 shows one of the twelve patterns available in demo. This should prove to be a good Rangoli tutor.

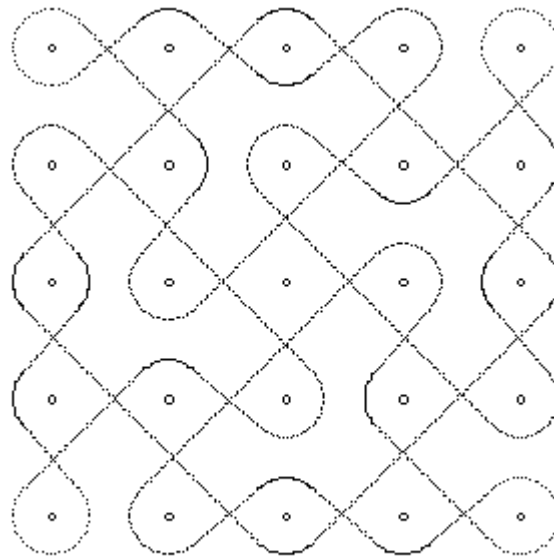


Figure 4 : Rangoli Pattern

Parabola in a rectangle- This is a standard construction in engineering drawing. There are six major steps involving 100s of lines. Computer states steps and shows construction line by line. Student can set the speed of his choice and repeat the demo till full understanding of the construction is achieved. Refer Fig.5

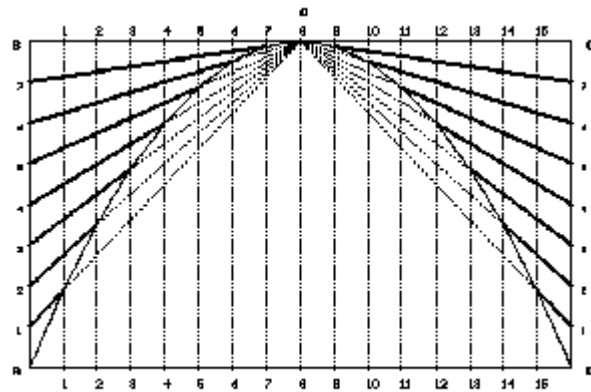


Figure 5 : Parabola in a rectangle

c) Virtual Laboratory

Some of the modules of virtual laboratory are as follows.

1) Velocity Ratio of Lifting Machines- There are many pulley arrangements to lead to desirable velocity ratio. The student can try the operation of machine to understand the velocity ratio. Fig.6 shows one of the lifting machines.

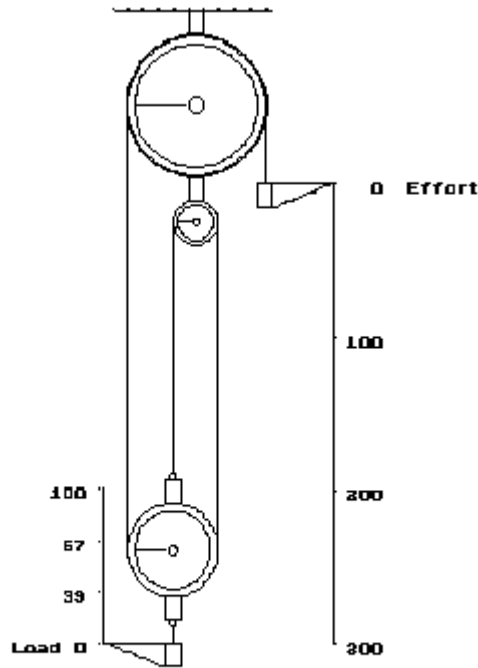


Figure 6 : Pulley block as lifting machine

2) Electronic Experiments- a laboratory containing 10 experiments of basic electronic has been developed. Here the student can choose the attributes of components to be used and then switch on the circuit. Experiment is performed over a range of values and graph plotted.

3) Discovery Learning

This demo is of finding maximum range of a projectile on a horizontal range. The projectile is projected at different angles. Computer shows the trajectory. Let us say that angle is varied at 10° interval, as one crosses from 40° to 50° , both these show the same range. One may explore the region between 40° and 50° at a lesser interval to finally prove that maximum range to be at 45° .

Validation of Formulas

Proofs of some of the formulae can be very easily demonstrated with the help of graphics. All the trigonometric formulae could be very easily shown. The module of $\sin(3x) = 3\sin(x) - 4(\sin(x))^3$ shows this.

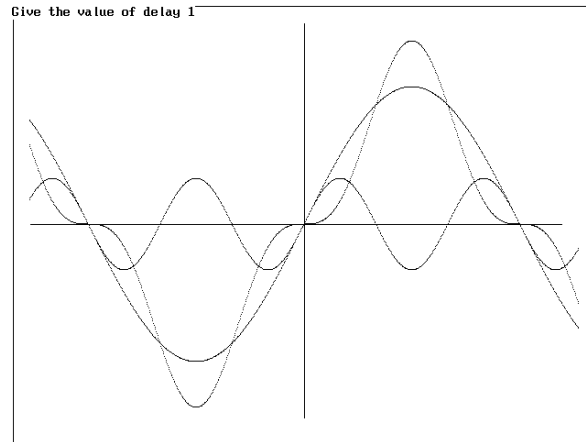


Figure 7: validation of formula

EPILOGUE

All teachers are requested to ponder on the points raised. They are requested to remove their computer illiteracy, if any, and work to prepare teaching material with the help of computers. This will make teaching of science subjects more efficient and effective.

Similar work is being done in Malaysian University for Multimedia (1) & in C-DIT Government of Kerala (India)(2).

References: 1) Animations in Calculus, Nur Azam Abu & Mohammad Talib, Proceedings of 35th Annual Convention of Computer

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