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Computers in the Science Classroom

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Introduction

Computers have become an integral part of the education system, and computer literacy is an important asset for any college student. Many students find that their exposure to computers at the high school level was not satisfactory. Thus they hesitate to enroll in computer enhanced mathematics or science courses at the college level. This paper discusses some of the avenues for secondary science instructors to incorporate computers into their current curriculum. It also examines computer use to enhance students' understanding of science and mathematical concepts.

Computers as a Writing Tool

The easiest way to incorporate computers into a curriculum is by requiring word-processed rather than hand-written reports. This is an ideal way to familiarize students with the machine and simple concepts such as file manipulation, text editing, document formatting and spell checking. Most students will be able to prepare a simple report on the computer with minimal help.

With hundreds of word processing packages on the market, which one should be used? The best approach is to leave that option open to the student. Some students are already familiar with a certain package, and there is no reason to force them to use other software. However, to get the students started, the instructor should select one or two packages and provide a simple handout which covers the basic commands.

Some instructors choose to give extra credit for word-processed reports. This approach is discouraged since it allows students to "skip" the system. Understanding how to prepare a simple report on a computer is beneficial to everyone.

Spreadsheets and Scientific Data

A typical laboratory assignment consists of theoretical background, collection of data and analysis. Any measurement invariably contains errors, and these errors are a major source of frustration for many students. The ability to understand the art of measurement and analysis of

data is essential for the successful science student. Elementary statistical analysis of data makes this possible. Simple manipulation of data challenges the student to understand the error and learn from it. Spreadsheets are ideal programs for such analysis. They allow the students to represent the collected data in a readable table format. Using the computer to do the cumbersome mathematical number crunching allows the students to concentrate on the data itself and formulate meaningful results from what they have gathered.

Nearly all spreadsheet programs allow representation of data through a variety of charts and graph configurations. Such results are ideal for inclusion in written reports or visual presentations. Spreadsheet programs also contain all the basic mathematical functions so that data manipulation is a matter of a few keystrokes. Such a tool is useful in labs where the students are to measure certain variables, then plug the values into a formula to find an unknown. If twenty measurements are made, the student must evaluate the formula with twenty different sets of data. This is a cumbersome calculation. A spreadsheet program requires one to enter only the data. The program will then apply the given formula to each set and formulate the result. Some labs require a large pool of data; students from several classes will need to take measurements. A spreadsheet is an ideal tool to compile a detailed statistical analysis from data gathered by different student groups.

Many commercial spreadsheet programs such as *Excel*, *Quattro* and *Lotus* offer educational discounts. Less sophisticated (and thus less costly) programs which require minimal hardware resources are ideal for classroom use. Teachers can find and evaluate these programs by browsing through popular computer magazines or speaking to members of a local computer club. In addition, many school districts hire computer coordinators who are responsible for computer instruction.

Computer Algebra Systems

Computer Algebra Systems offer a unique opportunity to explore science. Until recently, the huge computing resources required to run these systems limited their availability to researchers in top universities and commercial laboratories. Since the emergence of powerful desktop computers, some of these systems can now perform reasonably well on a personal computer.

Computer Algebra Systems offer a complete set of mathematical tools in a single system. Their uniqueness, however, lies within a new

approach to mathematical manipulation: symbolic manipulation. While computers have been crunching numbers for years, they have not been able to perform analytical manipulations. For example, many numerical techniques can evaluate the integral of a function over a certain interval, but unless the function can be found in an integral table, the evaluation of the indefinite integral is a formidable task. Computer Algebra Systems have the ability to evaluate a given integral symbolically. Of course, they also can find a numerical solution if the user so chooses. Therefore, they offer the best of both worlds. The symbolic capabilities are not limited to integration. They also include differentiation, simplification and matrix manipulation among many others. Such systems also offer exceptional graphing capabilities from simple two-dimensional graphs to sophisticated three-dimensional animation.

Incorporation of such a system in a science or math class can be achieved in one of two ways. The first approach allows the instructor to lead the students through the investigation of certain topics without concern for the students' mathematical background. Since the computer will take care of the mathematics, the instructor can focus on the concepts themselves. Topics such as chaos and electromagnetic fields, for example, require a strong calculus background. However, with the aid of a Computer Algebra System, the math can be virtually ignored or greatly simplified.

The second method is to allow the student to utilize the mathematical resources available in the program and investigate for themselves. A good example of such an approach is the study of waves in physics. The students can use the animation tools to create a simple cosine wave and study for themselves phenomena such as standing waves, harmonics and interference. Such manipulations are a matter of changing a few parameters in the given wave function. This intuitive approach along with a short lecture can be much more effective than looking at page after page of stationary diagrams and making the students responsible for imagining what would happen if the pictures were moving.

Two of the most popular Computer Algebra Systems are *Mathematica* from Wolfrem Research and *Maple* from Waterloo Software. Both offer educational prices for their systems and have versions for both Apple Macintosh and IBM compatible machines. Another system, which is less powerful but less resource-exhaustive is *Derive*, available from Soft Warehouse.

Computer Programming

The most versatile aspect of the computer as a machine is that it can be programmed by a user. Although there are many application programs which utilize the different capabilities of the computer, sometimes the only way to accomplish a given task is directly to program the computer to perform that task. In a classroom setting, the above scenario rarely occurs since many of the needed tasks can be performed by the existing software packages. Nonetheless, programming offers the student an insight into the logic that surrounds exact sciences. When a student writes a program to solve a given problem, he or she tends to say, "*I used the computer* to solve this problem." However, if the student uses a Computer Algebra System or a spreadsheet, she or he will tend to say that *the computer* solved the problem.

Since not all science students have an interest in computer programming, the best way to incorporate programming in a science course is through special projects and extra-credit work. Problems that require extensive and repetitive calculations, such as those involving probabilities, are ideal for beginning programmers. Almost all languages have a way of generating random numbers. This feature could be used to simulate simple games and calculate the probabilities experimentally. To go a step further, one can include problems in which some degree of decision-making is involved. For example, given a set of data, ask the student to calculate the standard deviation for that set. However, before including the data in the calculations, the students must make sure that the data is within a given range. For more complicated problems, an outline of the algorithm can be given so that the students will concentrate only on the code itself.

One question that instructors and students both face is the choice of a programming language. Once again, students should be allowed to choose a language which they know or find easy to understand. Since students come from different backgrounds, their programming experience is certainly different and they should be given the freedom to choose. Languages such as BASIC, FORTRAN and Pascal are simple, and numerous books with good examples are available in any library. These languages concentrate on the fundamentals and usually will warn the programmer of silly mistakes. Languages such as C or C++ are much more flexible and could easily confuse the beginner with their odd syntax and lack of warning signs.

Conclusion

This paper has discussed a few ways that computers could be incorporated into an existing science or math program at the secondary level. Although not all schools have the resources to utilize all the suggestions in this paper, to begin computer education at the high school level is very important. Students who choose not to attend college will have gained an invaluable experience which more and more employers are seeking. Students who choose to continue their education will undoubtedly use computers extensively during their college careers.

Computers are an essential tool in scientific research. They have played an important role in the advancement of science, and the human mind undoubtedly needs the aid of these machines to further explore the unknown.