Impact of statistical software packages on scientific research and statistical education

Statistical software packages have revolutionized the way we analyse scientific research data and also have transformed the way we impart statistical education. Before the availability of prepackaged statistical programs, the computational aspects of data analysis assumed priority over other skills. But nowadays, tedious calculations and formulae can be relegated to the computer. Packages can now analyse voluminous data sets or can perform statistically intractable complex methods easily. Such has been the extent of impact of packages upon scientific research that, with little or no knowledge of statistics, scientists can have their research data easily processed by a package that does the analysis for whatever sophisticated method they choose, of course, subject to its appropriateness. Thus software packages have made their impact heavily on scientific research in general and statistical genetics, breeding, agricultural field experiments, sample surveys, etc. in particular.

Exploratory analyses, which previously were avoided because of the time required to conduct them, can now be done using packages. The capacity of the packages to graphically display dynamic, interactive visual results can illuminate concepts, which without such illustrations have been much more difficult to comprehend earlier. For example, data fed can produce a histogram and data when updated synchronously, transform the histogram as well.

Thus the thirst for improvements in the way in which statistical education is imparted has been quenched by integration of software packages into the curriculum, not only as a data analytic tool, but also as medium for the illustration of statistical concepts[1]. One positive step in this new direction is the increasing presence of computer package output in statistical textbooks. Packages have affected the learning styles and have also changed the role of teachers. It encourages the students to play an active part in their own learning. The teacher changes from the role of a giver of information to a mentor who can guide pupils through methods and approaches in the package, and at the same time establish the links with related concepts through discussions.

Bringing computer packages into the theoretical course enables us to go far beyond the traditionally used small, artificial examples. In contrast, the use of real data in packages enables the student to make connections to a wide range of applications, thus enhancing the importance of statistical thinking. Moving from a formula to real data application was not always an easy task, as modern statistical techniques became more and more computational. Potential users of statistics have been faced with programming it themselves. Now packages hold the key to problems such as simulation, iterative methods, statistical modelling, etc.

The newly implemented initiative – GASP (Globally Accessible Statistical Program) web site has been developed as a primary listing of statistical procedures which can be used over the World Wide Web (WWW)[2]. They facilitate dynamic, interactive, prepackaged programs which run over WWW, for example, routines written in standard statistical packages such as SAS (Statistical Analysis Systems) can be initiated from the HTML document.

Spatial and quantitative information on land use, land cover, etc. is becoming vital for scientific planning, coastal monitoring and sustainable management of natural resource, at local and global scales. Geographic Information System (GIS) packages such as ArcInfo, Arcview, etc. have made their useful impact in such areas. Also, for interpretation of large quantity of remotely-sensed image data, automatic recognition of land-use categories can be made by utilizing the classification algorithm modules of these packages. Now, a word of caution. Use of statistical packages without the help of statisticians may have potential dangers. We should always keep in mind that packages can supplement statistics, but cannot substitute them. The neatly printed output of packages looks so authoritarian that any statistically weak novice will accept it as a gospel and can have his/her own conclusions. Amidst these, with rising expectations, let us hope that statistical packages will continue to assume a role of increased importance in scientific research and statistical education.

1. Higgo, J., *Teach. Stat.*, 1993, **15**, 57–59.
2. West, R. W., Ogden, R. T. and Rossini, A. J., *Am. Stat.*, 1998, **52**, 257–262.

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Plugging the brain drain: An ecologist's view and a cartoonist's perspective

Every year, a sizeable number of Indian scientists migrate to the developed world, lured by jobs and prospects of a better life. In today's globalized set up, while such a movement cannot be considered as unusual, some amount of concern has naturally been voiced. For instance, it has been argued that since most scientists are trained at the expense

of the state, at very subsidized rates, it would be reasonable to expect that they will someday repay by contributing to developments back home. However, the fact that a sizeable number prefers to emigrate leads to a malaise that is perhaps best understood by the term 'brain drain'.

My contention is that migrating to the West cannot be the best professional strategy for all kinds of scientists, and indeed in some areas of biological research, notably ecology and biodiversity conservation, it would be a sensible strategy to stay back or return after receiving training in the West. Two, seemingly disparate streams of activity may be identified in biological sciences research, namely cellular and subcellular biology (including biochemistry, molecular biology, etc.) and organismic biology (physiology, ecology, biological conservation, etc.). In most problems it is the question being asked which is of paramount importance, and the application of research techniques can often blur the distinction between these two disparate areas. For instance, in an ecological study of mating patterns of birds, a molecular biology technique (such as DNA fingerprinting) may be employed to understand the exchange of genetic material among individuals.

An individual biological scientist, in an attempt to maximize his/her professional success is of course free to migrate, with the least consideration about 'brain drain'. However, a molecular biologist may work on a process, which is unlikely to be influenced by geographical location. A molecule is the same whether it is being studied in New York or New Delhi. Similarly, a basic life process being studied using standard models such as *Drosophila*, *E. coli* or the white rat is unlikely to be influenced by where and, in which part of the world the study is being done. In all probability, such work pursued in the West, generally yields better results for reasons which are well known (these include the availability of state-of-the-art facilities and a good working environment).

But as regards field ecology, the location of the study area matters. Biological scientists, with an inclination towards organismic biology, who migrate to the West, leave behind an area of immense richness and a plethora of interesting research problems which arise out of the complex interactions in the tropical world. Also, and significantly, since much of this biodiversity is gravely threatened, there is an urgent need for scientists to find solutions for its conservation. This brings us to the crux of our argument that, given a choice, it is a better professional strategy for a scientist from India to stay back or return. Not only has the wealth of biodiversity in India been properly documented and classified; hidden underneath, there are interesting ecological relationships which have not yet been fully and properly understood by the application of the methods of modern scientific inquiry. Consequently, by taking up novel problems in a biodiversity-rich area, one can earn a name for oneself very soon.

An analogy could be made to that of an artist who, in a certain sense, draws sustenance from the disorder and squalor of his underdeveloped, native country. The career of India's foremost political cartoonist, R. K. Laxman would be an apt example because it throws some light on the type of dilemmas which can confront an ecologist on the threshold of emigration. Early in his career Laxman was offered a job with a London-based newspaper, but due to some reason he kept postponing his departure, much to the chagrin of his prospective employer and to the annoyance of his friends, who predicted that like everyone else, Laxman too would eventually settle in the US. But, as Laxman writes in his autobiography[1]: 'People who were celebrating my potential British citizenship had no idea of the nature of my work. Perhaps they thought of me as one among the doctors, engineers, businessmen, shopkeepers who happily emigrated and continued to do their work abroad. But mine was a different profession. The conformity and uniformity of that country's social life and the propriety in political conduct would have reduced me to a mediocre illustrator of events. I would have missed the multifaceted, colourful life of India, whether social or political, that I lived with and understood. Finally, I decided that it would be a great mistake to uproot myself and succumb to the glamour of living in a foreign country.'

A possible extension of the above argument is the suggestion that it is only worthwhile for ecologists to stay back/return to India and that other biological scientists are better-off abroad. However, clearly that is not being said here. Secondly, whether foreign-trained Indian scientists who decide to walk on the road less travelled by can manage to get worthwhile jobs back home and can perform as well as they would do in the West, is an altogether different matter.

1. Laxman, R. K., *The Tunnel of Time*, 2000, Penguin India.

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Evaluating palaeontology and palaeontologists

A well-written article by Mukund Sharma (*Curr. Sci.*, 2002, **82**, 913–917) emphasizes the fading of the field of palaeontology in India. Though it is in the hands of policy-makers to take a firm decision concerning rejuvenation of palaeontolgy in India, palaeontologists have to unite to present a correct perspective of this science before the general public and get a positive response from the decision-makers.

A few points which have either not been emphasized or not adequately dealt with in the article need to be addressed. Palaeontology is suffering, first because of the traditional approach of the palaeontologists, especially in the era of multidisciplinary sciences, and secondly because of lack of awareness among people about its potential role in society and nation-building. For example, it is