20. HOW TECHNOLOGICAL INTRODUCTION CHANGES THE TEACHING OF STATISTICS AND PROBABILITY AT THE COLLEGE LEVEL

Susan Starkings
South Bank University

INTRODUCTION

During the past few decades, technological resources have become widely available for use in the teaching of statistics. This is particularly true in developed countries; developing countries are catching up at a slower pace. Technological resourses, such as electronic calculators and computers, play a significant role, not only in the classroom environment but in everyday life (e.g., in supermarkets, the banking industry, and travel agents). Above all else, the progress in computing technology has had an important effect on statistical education. This, coupled with the pressing considerations of the requirements of statistical courses, has resulted in changes in how statistics is taught. The recommendations made by the Round Table Conference in 1984 are examined here by commenting on the outcomes of these recommendations and looking at new advances in technology and their applications. Work currently being conducted in Pakistan will be reported, as well as the implications of this for other developing countries.

THE ROUND TABLE CONFERENCE IN 1984

The recommendations made to the ISI Education Committee by the Round Table Conference on the Impact of Calculators and Computers on Teaching Statistics (Råde & Speed, 1984) are as follows. (Note that these recommendations are the result of much professional research that was brought together at the conference under the chairmanship of Lennart Råde.)

1. Calculators and Computers as Statistical Tools

- Calculators and computers must be recognized as tools of basic importance, be available to all teachers and students, and teaching methods and syllabuses should take account of these resources.
- Educational authorities should be encouraged to include statistical courses that make full use of the computers and calculators available. In all countries, it would be desirable to teach statistics as early as possible. Real-life statistical examples should be experienced by students by the ages of 11-12

years. In developed countries where calculators and computers are available they should be used as companion tools in statistical instruction; in developing countries, solar-powered calculators would be advantageous.

2. Teacher Training and Retraining

- The training of new teachers and the retraining of existing teachers is essential so that full use of these technologies can be successfully implemented in the classroom.
- Computational statistics workshops, such as those organized by various national statistical societies, should be greatly encouraged.
- National projects such as the Quantitative Literacy Project in the USA should receive firm backing and the results obtained should be disseminated internationally. Other countries should be encouraged to set up similar research projects.

3. Educational Research

- Continued research into teaching methods should be conducted to determine:
  - (a) at what age and through what methods statistical concepts can be effectively learned by children,
  - (b) the stage at which calculators and computers can best be introduced in the teaching of statistics;
  - (c) for what purposes calculators and computers are best suited; how developments in technological resources change statistical courses and syllabuses.
- To what extent does program writing aid the logical and quantitative skills of students and how can statistical packages be developed, adapted, and improved.

4. Text and Software Development

- The development of new books and educational material is required to make use of the new resources available; the development of statistical software for inclusion into statistical lessons should be monitored and evaluated.
- The review of text and software should be the responsibility of statistical journals, such as *Teaching Statistics*.

5. International Cooperation and Communication

- International cooperation and dissemination is essential.
- Computer networks for dissemination of data and information should be encouraged.
- An international magazine for dissemination should also be produced.

6. Manufacturers of Calculators and Computers

It is in the interest of manufacturers to support the use of their equipment in the following manner:

- Produce relatively cheap calculators and computers suitable as teaching aids.
- To support the ISI educational committee

To some extent, the teaching of statistics has changed because of the recommendations made above. Whether full use has been made of the technological resources available is a matter open for discussion and beyond the scope of this paper. However, the use of calculators and computers in developed countries is prevalent and firmly established within educational institutions. Teacher training, both initial and subsequent, now incorporates the use of these new technologies. Continuation of training is paramount, particularly for future technological advances, if these advances are to be implemented and used within the classroom environment. The ISI has recently established the International Association for Statistical Education (IASE). One of the tasks of IASE is to increase membership and to provide a forum where members can meet and discuss statistical education matters. Technology plays an important role in this organization, from the dissemination of information to hosting sessions (at related conferences) about how technology can be used to benefit statistical education. For example, the IASE organized several sessions at the 50th session of the ISI in Beijing 1995. “The statistical education sessions were well attended with contributors from many different countries. Contributors provided papers on topics where the use of technology played a prominent role and advocated using computers in statistical education to elucidate important and relevant points” (Jolliffe, 1995, p. 2).

The use of electronic means of communications, such as electronic newsletters and journals, has greatly increased over the last decade. *The Newsletter of the International Study Group for Research and Learning Probability and Statistics* is a typical example of how the electronic highway is now used to disseminated information. Note that this newsletter is available in hard copy for those interested parties who do not have an e-mail address. The *Journal of Statistics* is available to all those who have the technology to access it. The areas of educational research, the production of relevant text and computer software, international cooperation, and manufacturers support have been addressed since 1984, but they must continue to be addressed because technology is continually changing. Computers and calculators are not the only technological resources that are available. Videos, radios, and electronic media, such as the growth in e-mail, the World Wide Web and the internet, have become available and used within some educational institutions. Developing countries have limited access to technological resources. However, the use of calculators in these countries is becoming more frequent.

TECHNOLOGICAL RESOURCES

The growth in teaching statistics is a feature of the twentieth century. This teaching has benefited from the development of the technological resources that are available. One must always keep sight of the basic aim of statistical education, which is to educate the student to use statistical techniques appropriately. Arnold (1993) pointed out that “as educators, we need to work at and improve the techniques we use” (p. 170) and that “the overweening desire for technology can blind us to problems, perhaps making us forget our reasons for looking to technology in the first place, which is to improve our students' and our own learning. It takes more than technology alone to truly make a difference” (p. 171). Technology can be used to enhance our teaching, but, hopefully, not be seen as a replacement for teaching. The examples provided here need to be examined, and it needs to be determined whether they are suitable for inclusion in statistics or statistics-related classes.

Examples

When using any calculating device it is important to realize that errors can occur. If a computer is to be used, one must realize that the storage capacity for each number is limited. Also, computers operate in binary, not decimal numbers. For example, note that 1/3 is an infinite decimal number of 0.333333...; in binary 1/10 has the infinite binary representation of 0.0001100110011..., which cannot be stored exactly in the computer. Cooke, Craven, and Clark (1985) demonstrated the effect of this by running a short program in Pascal. The program is as follows:

```
program add (input,output);
var     i : integer;
        t : real;
begin
        t := 0;
        for i := 1 to 500 do
        begin
                t:= t + 0.1;
                writeln (t);
        end
end.
```

Early use of computers often involved students writing programs to perform calculations or observing the outputs from such programs. The above program is a typical example of these early programs used in statistical education. Today it is likely that a software package would be used instead. The storage capacity of machines has increased vastly so that round-off errors are not as obvious. However, errors do occur and students should be aware of this possibility. The approach may be different, but the underlying problem still exists and needs to be elucidated.

Students who are following a combined study of computer programming and statistics may still write statistical programs. Students have to fully understand statistical techniques before they can successfully program them. However, the time involved in producing software may not be a profitable use of their time. Modern software packages include statistical features that may fulfill the educational outcomes that are to be achieved, without the need to produce lengthy software. The teacher is the best judge of the type of assessment required for his/her students. For example, for students following a combined study of computer programming and statistics, Cooke et al. (1985) had students fit an exponential distribution to a set of data for their assessment (see Figure 1).

This question could be modified for students who are not studying both computer programming and statistics. The question would have the same underlying statistical question and the same data, but software such as a spreadsheet or a statistical package such as Minitab could be used to answer the following questions (which would replace Parts 1-4 in Figure 1):

1) Using appropriate software fit an exponential distribution to the above data.
2) Carry out a goodness-of-fit test of these expected frequencies to those observed.

3) Printout the observed values in each interval, the corresponding expected values, the chi-squared value from the test and its number of degrees of freedom.

Question: The life-times of 500 items of a particular electrical component have been summarised in the following frequency table.

Time (hours)	Frequency
0-99	208
100-199	112
200-299	75
300-399	40
400-499	30
500-599	18
600-699	11
700-799	6

(1) Write a section of program that will estimate the mean of these observations.

(2) Continue the program by finding the expected frequencies in an exponential distribution with the same mean.

(3) Carry out a goodness-of-fit test of these expected frequencies to those observed.

(4) Printout the observed values in each interval, the corresponding expected values, the chi-squared value from the test and its number of degrees of freedom.

Figure 1: Example of assessment given by Cooke et al. (1985)

Cooke et al. (1985) also considered the accumulation of round-off error and loss of significant digits, which can invalidate a calculation completely. The example they showed was

$$f(x) = \frac{p}{1 - x^2} \qquad \text{for } p = 0.3 \text{ and } x = 0.99900050$$

Because of rounding, they found x = 0.99900000 (an error in the seventh decimal place). The result obtained is 1500.7504, but it should be 1501.50075. An error in the seventh decimal place has produced an error in the fourth significant figure of f(x). The crucial step here is subtracting x^2 from 1. Because these numbers are very similar in magnitude, it leads to significant digits being lost in the divisor. Using a modern calculator, the result obtained would be 1501.50075 and hence would not be seen as a problem. Teaching must take new advances in technology into account, but the examples used must be adjusted for the specific technology used.

The topic of combinations has long been a part of statistics. Combinations can be taught as a single topic or as part of the binomial distribution. The formula is:

$$^{n}C_{r} = \frac{n!}{(n-r)!\,r!}$$ where n factorial is written as n! and defined as $n! = n \times (n-1) \times (n-2) \ldots \times 3 \times 2 \times 1$.

Students must know when to use the combinations formula and what the values of n and r are. This is fundamental to the understanding of the topic and is unlikely to be replaced by technology. However, the calculations one must do have changed because of the introduction of new technology. Before this new technology, the student would be taught how to reduce n!/(n-r)!r! to its simplest form.

For example, if n = 10 and r = 4,

$$\frac{10!}{(10-4)!\,4!} = \frac{10!}{6!\,4!} = \frac{10\times9\times8\times7\times6\times5\times4\times3\times2\times1}{6\times5\times4\times3\times2\times1\times4\times3\times2\times1}$$

which reduces to $\frac{10\times9\times8\times7}{4\times3\times2\times1}$ and by further cancelling is 10x7x3 = 210.

With a modern calculator, the above calculation can be done instantly with the touch of a button. Hence, the above information no longer has to be covered by the teacher. It can be argued that being able to reduce n!/ (n - r)! r! to its simplest form is still a useful skill for a student to acquire. Some calculators have the n! function but do not have the $^{n}C_{r}$ function. If this is the type of calculator being used then the student has to understand how to implement the $^{n}C_{r}$ formula rather than just how to input the values of n and r.

It is necessary to take into account the diverse amount of statistical experience each student brings to the classroom. By investigating this statistical experience, educational institutions can work toward a combined approach that satisfies educational academic rigor, industry needs, and the criteria of professional associations. As technological resources increase, students will bring with them a different set of statistical experiences. The knowledge they have gained can be used and built on. The main problem arises when the students bring along different technological skills and devices.

The example provided in Figure 2 is from a computer-based modeling course for mathematics and statistics that is designed to allow students to develop and explain solutions that are conducive to their respective backgrounds.

Question: Computer Based Modelling Spreadsheet Assignment

Spreadsheets are used extensively in Modelling. Choose a spreadsheet and describe what features make it a useful piece of software to be used for modelling. Give suitable examples to illustrate the features you have identified. The examples must be printed out from your spreadsheet with suitable annotation. Evaluate the spreadsheet as a tool to be used (Starkings, 1993).

Figure 2: Example of the computer based modelling spreadsheet assignment

When answering this type of question, the students go into detail and explain examples such as decision trees, statistical hypothesis testing and forecasting methods, and how the spreadsheets could be used to hold respective formulae to calculate the test statistics or decision trees probabilities. Figure 3 shows an example of a decision tree (Wills, 1987).

Computer Spreadsheet layout and results

	A	B	C	D	E	F
1	Minimum	Market	Results of	Maximum	Probability	Value
2	Maximum	Research	Market	Loss Given	Success/	Successful/
3	Expected	Costs	research	Best Action	Failure	Unsuccessful
4	Loss (Best		Survey			Product
5	Value in					
6	Centre)					
7						
8	**********	**********	**********	**********	**********	**********
9			Category A		0.5	$1,400,000
10			0.4	$350,000	0.5	($350,000)
11	$312,500	Survey				
12		$50,000	Category B		0.9	$1,400,000
13			0.35	$350,000	0.1	($350,000)
14						
15			Category C		0.15	$1,400,000
16	*********		0.25	$0	0.85	($350,000)
17	$312,500					
18	**********					
19	$350,000	No Survey			0.5525	$1,400,000
20		0$		$350,000	0.4475	($350,000)

Computer Spreadsheet Formulae

	A	B	C	D	E	F
1	Minimum	Market	Results of	Maximum	Probability	Value
2	Maximum	Research	Market	Loss Given	Success/	Successful/
3	Expected	Costs	research	Best Action	Failure	Unsuccessful
4	Loss (Best		Survey			Product
5	Value in					
6	Centre)					
7						
8	**********	**********	**********	**********	**********	**********
9			Category A		0.5	1,400,000
10			0.4		1-E9	-350,000
			@IF(E9*F9+E10*F10>0,-F10,0)			
11	+B12+C10*D10+C13*D13+C16*D16					
12		Survey 50000	Category B		0.9	+F9
13			0.35		1-E12	+F10
			@IF(E12*F12+E13*F13>0,-F13,0)			
14						
15			Category C		0.15	+F9
16	*********		0.25	1-E15	+F10	
			@IF(E15*F15+E16*F16>0,-F16,0)			
17	@MIN(A11,A19)					
18	**********					
19	+B20+D2		No Survey	+E9*C10+E12*C13+E15*C16	+F9	
20			0$	@IF(E19*F19+E20*F20>0,-F20,0)		+F10

Figure 3: Decision tree example

The students can use the spreadsheet model in Figure 3 to examine various decision alternatives, such as if the probability of success/failure changes for category A. The calculations are almost immediately done, and the student can make comments and recommendations on the results. The student must know how to set up the decision tree correctly to be able to use the spreadsheet. Previously, the student would draw out the decision tree and perform numerical calculations by hand, or calculator if available. Any change in the probabilities would result in further hand or calculator calculations, which takes time and introduces the likelihood of an arithmetic error, before any recommendations could be made. Spreadsheets, provided they are used correctly, can perform numerous calculations without the chance of numerical error. However, Figure 4 shows an example where a spreadsheet could be misused.

Question: A school shop has kept record of its sales during the last week. The sales have been summarised in the following frequency table.

Item	Number sold
Crisps	100
Chocolate Biscuits	75
Cheese Biscuits	50
Cereal Bars	69

Use a spreadsheet to graphically display the data above.

Figure 4: Example of possible misuse of spreadsheets

Holmes (1984) states that "...a picture is worth a thousand words. It is not so obvious that a picture might be worth a thousand figures. There is no doubt that many people find it easier to see the overall pattern from a graph than from a set of tabulated data. Good teaching programs can show what is gained and lost by moving from one form of representation to the other" (p. 90).

A student can enter the data and produce a variety of graphical displays such as bar charts or pie charts, which are acceptable diagrams. However, the student could also produce a time series graph, which would be incorrect for the above data. Hence, software can produce diagrams at the touch of a button, but the relevant statistical knowledge that the students need in order to use the correct graph must be taught in advance. A typical answer/argument from a student is that the computer cannot be wrong!

"The quality of teaching and learning across the country also depends on ensuring that the most refined advanced skills in pedagogy become over time the collective possession of the profession" (Barber, 1994, p. 7). Statistics is a subject that is both theoretical and practical by nature and needs to be addressed in both of these aspects. Reforms in the teaching and learning of statistics are required if the profession is to encourage users to use statistics in a practical context. This is not to suggest that reforms of recent years are detrimental but rather to suggest that perhaps the time has come to shift the focus from theoretical statistics

to that of a more practical nature that can be understood by the students. Some developing countries, like Pakistan, still follow a theoretical pattern. Unless statistics is seen as relevant to students, all too often a low priority status is given to the subject and accorded minimal attention by students. This in turn leads to statistics teachers becoming despondent. A policy in which both aspects of statistics is addressed is surely desirable in educational terms.

"Policy should be designed to cherish and restore the sense of idealism which is the core of all good teaching, and to provide the opportunity for teachers to work constantly at refining and developing their skills" (Barber, 1994, p. 7). For example, the use of videos has brought a new dimension to the teaching of statistics. This method of communication can be used when visual impact is desirable or for students who missed the lesson. Television programs can be taped and viewed when required. In some cases, lessons are taped and shown to classes who are at a different geographic location. In Canada, interactive video lessons have been used. Thus, the 'expert' can deliver the lesson in one Canadian state and another Canadian state can interact wiht that classroom as if they all were in the same classroom, via the video link. The teaching can then take place over a large distance. The receiving state has a teacher in the classroom who acts as a facilitator of learning rather than the person delivering the lesson.

PAKISTAN

When this article was written, the schools in Pakistan did not yet have access to computerized technology, such as e-mail, the internet, or software packages such as Minitab and spreadsheets. However, calculators are used in the more affluent schools and colleges. Developing countries are behind in their use of technology simply because they lack the necessary resources. Any advice or lessons that developed countries have gained through the use of technology can be of benefit to these developing countries.

Due to the direct link between a country's socioeconomic conditions and its system of education, the situation of statistical education in underdeveloped countries is completely different than in the developed world. International organizations, such as ISI and IASE, have an important role to play in assisting colleagues in underdeveloped countries. For example, it may be appropriate to have teacher exchange or teacher training programs or to offer support to centers currently involved with statistical education. Developed countries need to be aware of the lack of resources that currently exist in developing countries, such as Pakistan, which has severe shortages of textbooks and calculators. Furthermore, in most developing countries there is a general lack of computing facilities.

In Pakistan, statistics is taught as a separate subject at first degree (i.e., the undergraduate level) and above. Note that it is rarely taught before students reach this level. The work students do tends to consist of lengthy numerical questions that are solved by students using calculators or log tables, with little, if any, discussion of, or implications of, the results. Absence of practical projects in the statistics curricula during the past 40 years has resulted in the students passively accepting the information provided rather than solving real-life problems. Kinnaird College in Pakistan has organized an annual Statistical Exhibition for the last 6 years, as well as the Statistics Teachers' Educational Programme. This year external funding has been provided by this author in order to award a prize in Statistical Education and Research.

During 1990, Kinnaird College organized a practical statistics competition and had a few entries; however, the effort made by the college and support from teachers in the country has led to its rapid growth. Now the college also provides an annual prize, which is given at the same time as the country's annual Statistics Training Education Programme award.

Because statistics is a practical subject, the syllabus for a statistics course should be designed so that the concepts and methods are introduced so that the students both achieve the aims and objectives of the course and develop a better understanding of the subject. During 1993, a statistics practical was introduced that had a 15% weighting as part of the examination. Although this is a major step for Pakistan examinations, these practicals are very much, at the present moment in time, prescribed.

The University of the Punjab (1993) states the following about the practical examination: "The Practical Examination will be carried out in laboratories with the help of coins, dice, cards, random number tables and other such materials. A minimum of 20 practical should be carried out" (p. 9). The content of each section is then stated. For example, "Between 50 and 100 observations to be obtained from experiments. Various measures of central tendency and of dispersion are to be calculated" (University of the Punjab, 1993, p. 12).

Statistics teachers in Pakistan are finding it very difficult to administer these practicals because they involve a considerable amount of time, especially considering the calculations are usually done manually. The teachers feel that they do not have adequate experience in carrying out and assessing this type of work and that there is a need to teach statistical methods that are pertinent to real-life as opposed to just teaching statistical techniques. Association with other countries who are familiar with this type of work is essential in order for Pakistan statistical education to develop. When technological resources become available, then meaningful datasets can be collected or simulated and analyzed electronically. This will save a considerable amount of time (that previously was used doing the calculations manually).

The students also must complete two written papers. The questions on these writtens are calculation-oriented. A typical question provides some values, that are not always put in context, and asks the student to calculate some statistical measure. For example, "The Reciprocals of certain values of X are 0.004, 0.0625, 0.05, 0.025, 0.02, 0.125, 0.333, 0.0125, find the arithmetic mean of X" (Beg & Mirza, 1989, p. 7). This type of question is also what is presented in the statistics courses. A broad statistics curriculum is not only desirable but essential, because students do not learn by having facts hammered into to them and by rote learning of how to answer questions. Pinder (1987) suggests that "Most rote learning unless accompanied by understanding, does not remain in the memory. To be retained learning must be understood, and skills practised in a variety of ways" (p. 51). It is essential that syllabi, curriculum, and examinations for statistics are altered in such a way as to provide students with a forum for applying and understanding statistics in a variety of contexts.

The Statistics Teacher Education Programme (STEP) began in the early part of 1992; thus far, eight training sessions have taken place. Kinnaird College Statistics Teachers comprised the first team: They set up the training program and provide support to other statistics teachers. Each of the eight sessions has focused on a different element of statistics. For example, the STEP 3 session concentrated on how to devise, conduct, and assess statistics practicals. A future STEP session could be used for looking at how to use technology in statistics practicals. Technological resources would need to be available so that teachers could then implement any techniques required.

The Annual Statistics Competition is run by Kinnaird College and a considerable amount of progress has been made over the last few years in trying to demonstrate the practical uses of statistics. This has been partly achieved by the Inter-Collegiate Statistical Competition. The rules of the competition are summarized as follows:

1. Students may participate in this competition individually or in teams of two or three students from

the same college.

2. Each student/team must conduct out a statistical project as follows:
   (a) Decide what is it that you want to find out (e.g., you may wish to examine the proportion of students who take tuition, where tuition means that a student has private tuition in addition to their normal college lessons).
   (b) Collect primary data (real, unpublished data) in order to find a reasonable answer to your question.
   (c) Analyze the collected data and draw a conclusion; state the limits of your conclusion.
   (d) Present your project in the form of a poster.

Kinnaird College students were not allowed to enter the competition, to insure the host college would be neutral. In the future, it is hoped that technological resources will be used to analyze data. Entries varied for the above competition. Example of titles submitted include: "Population of Family re: Education Level," "Why do people take exercise," "Liking or Disliking of Dish Antenna," "Crank Calls," "Smoking and Spirits," "On what basis do people caste vote," and so forth.

Working in an educational system that is predominantly textbook-oriented this initiative was to try out new methods for effecting change. Pakistan is ready for technology to be introduced because the teachers and students are responsive to changes in teaching methods and strategies. The competition certainly encouraged statistics teachers to discuss with each other ways of encouraging their students to be involved in practical work and about how to use technological resources. A forum in which teachers can discuss ideas and ways of improving their teaching provides mutual benefit to the students and the progression of statistics in Pakistan.

SUMMARY

Educational establishments have the daunting task of updating the curriculum to keep pace with changes in society and the work environment, of deciding what should or should not be included in statistics courses, and how to structure such content to give a logical flow and meaning to the rest of the courses that the students are studying. Technology is and will be a major part of our everyday life and is increasingly being used as a teaching resource in many different forms. It is difficult to say what technological developments will be next, but our teaching techniques and styles will inevitably be altered to accommodate these new resources. Developing countries can and should learn from the developed world so as to make the most profitable use of new technology.

The paper illustrated areas where technology has been introduced and how teaching has adjusted to include the new resources. The experiences that have been gained from Pakistan are invaluable and suggestions on future work in Pakistan have been put forward for consideration. This paper attempted to identify the nature of the problems and, in some instances, to indicate how they themselves might be used in statistical-based courses. Because of the fundamental importance of these problems there is a need to discuss them further, thereby adding more understanding to what is required to provide solutions.

REFERENCES

Arnold, T. (1993). The role of electronic communication in statistics education. *Proceedings of the First Scientific Meeting of The International Association of Statistical Education* (pp. 161-172). Perugia, Italy: IASE.

Barber, M. (1994, March 19). Born to be better. *Times Educational Supplement*, p. 7.

Beg, A., & Mirza, M. (1989). *Introduction to statistics*. Lahore, Pakistan: The Caravan Book House Publishing Company.

Cooke, D., Craven, A. H., & Clarke, G. M. (1985). *Statistical computing in Pascal*. London: Edward Arnold.

Holmes, P. (1984). Using microcomputers to extend and supplement existing material for teaching statistics. *Proceeding of the Sixth International Statistical Institute Roundtable Conference on the Teaching of Statistics* (pp. 87-104). London: Chartwell-Bratt Ltd.

Jolliffe, J. (1995). Education report for the Royal Statistical Society News. *Statistical Society News, 23,* 2.

Pinder, R. (1987). *Why don't teachers teach like they used to?* London: Hillary Shipman Limited.

Råde, L., & Speed, T. (Eds.). (1984). The impact of calculators and computers on teaching statistics. *Proceeding of the Sixth International Statistical Institute Roundtable Conference on the Teaching of Statistics* (pp. 7-20). London: Chartwell-Bratt Ltd.

Starkings, S. (1993). *Computer based modelling assignment* (course notes). London: South Bank University.

University of the Punjab. (1993). *Syllabi and courses of reading statistics: FA/FSc classes XI and XII intermediate examinations.* Lahore, Pakistan: University Press.

Willis, R. J. (1987). *Computer models for business decisions*. London: Wiley.