Industrial Visits Work

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Bill Gibson
Royal Grammar School, Newcastle upon Tyne, England.
e-mail: bill.gibson@schools.ncl.ac.uk

Summary
Visiting industry to see how statistical methods are used in practice is well worth the time and effort which are involved.

◆INTRODUCTION◆

IN COMMON with most teachers in schools, I suspect, I find it difficult to create the time or to summon the energy to do much more than what is required by the job of teaching. Arranging and making visits to the outside world of industry certainly requires an effort, and so it is necessary to ask what are the benefits. In the light of my experiences in the last few years, I am very positive about such visits and feel that they are valuable for teachers and consequently for their classes.

Having followed the route from school to university to Postgraduate Certificate in Education to teaching, I had had minimal contact with the non-academic world. For about fifteen years I was content to teach mathematics - pure, mechanics and statistics - without much thought about the applications of the subject. I enjoyed the theoretical side of mechanics and statistics, as well as the challenges in pure mathematics itself. There was sufficient interest in mastering the subject and sufficient challenge in controlling, and occasionally motivating, the pupils to keep me from looking outward.

One of the extra roles which I had acquired in school was to be part of the "careers team". This entailed discussing with 15- and 16-year-old pupils the examinations (A-levels and AS-levels) which they planned to take at the end of their time at school, and their thoughts about degree courses and careers. Perhaps it was this which helped to motivate me to try to find out something about the applications of mathematics in the outside world.

My first few visits to local industry were to find out about the applications of statistics and mathematical modelling. It so happened that, for one year, I had a timetable with some early finishes and I also had the enthusiasm for finding some people who would allow me to visit them. One of the most interesting applications of mathematical modelling which I met had been done by a firm producing the basic pigment for paint. The basic material is fed in at the top of a rotating cylinder, whose axis is inclined to the horizontal, and hot gas is fed in at the bottom. The conditions inside the cylinder had been modelled using differential equations. The model could then be used to find the optimum temperature, angle of inclination and speed of rotation. It is only recently that I have appreciated the role which statistics (could have?) played in designing the experiments to obtain the initial data for the model and in quantifying the fit of the model and hence of the predictions obtained from it.

The following year my timetable wasn't really amenable to my making visits and there seemed to be more internal pressure that year. Therefore my industrial visits came to an end. About five years ago I was asked to write an A-level text on *Commercial and Industrial Statistics* (Gibson, 1997) and, as you might guess, this motivated me to start visiting people in industry again. Having visited about thirty such people, and spoken to scores more by phone, I am able to say that I have found the contacts interesting and worthwhile.

◆REASONS FOR◆ INDUSTRIAL LINKS

So, what are the benefits from contacting statisticians and visiting them in their places of work which, as far as I am concerned, make the time and effort worthwhile? Briefly, they are as follows.

- Industrial visits provide the teacher with some answers to the perennial questions: "What is the point of this?" and "Who uses this outside of

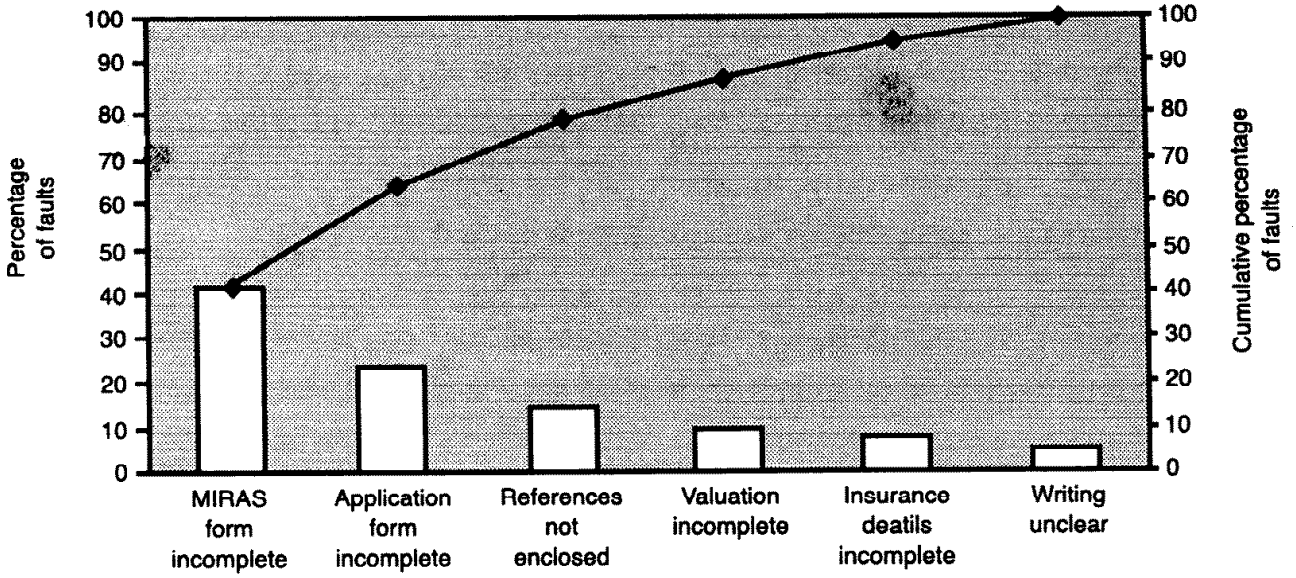

Fig 1. Pareto chart for faults on home loan applications

school?"

- Industrial visits provide a source of real(istic) examples to be used in class to practise the standard methods and a potential source of data for coursework.
- Industrial visits provide some stories which may be used to add interest to lessons.

When I have taken pupils on an industrial visit, I have been surprised afterwards by the amount which they have remembered and understood. However, 1 should admit that I organise very few such visits, partly because of the difficulty in arranging them and partly because of the need to ensure that there is something relevant for the students to see and a good person to explain to them what is going on.

◆EXAMPLES◆

Let me illustrate some of the above points. Clearly, the things which I remembered from my visits were what interested and appealed to me. No doubt others would have been interested in different aspects of the situations.

Bar charts and cumulative frequency plots are quite flexible and easy to construct, but I had never found any reason to be particularly enthusiastic about them. However, when I found them used as Pareto charts to prioritise action in reducing the number, or cost, of defective (non-conforming) items being produced, I began to look at them in a new light. For example, several precision engineering firms which I visited would speak of "Paretoing" a section of the production line which was producing faults and causing them to reject the final item. By doing this they were able to identify the main causes of rejecting faulty items rather than just targeting what they imagined to be the problem.

Figure 1 shows an example in a different context. The chart makes it dramatically clear that the main cause of faults here is incomplete MIRAS forms (MIRAS is the tax relief system for mortgage payments in the UK), so this is the part of the process that should be improved first. Of course such a chart is a very simple idea! But, by preparing one, attention is *forcefully* directed to the main causes of problems.

Making sense of a mass of data, and then making a management decision about what action to take, can show pupils the value of simple statistical techniques and can prepare them to encounter these techniques when they start work.

The binomial distribution is a standard component of any A-level course in statistics. However, examples on the number of heads obtained in four throws of a coin or the number of left handed pupils in a class may be easy to envisage, but they are not exactly earth shattering. On the other hand, the application of the binomial distribution to checking the quality of components supplied to a factory and deciding whether to accept the batch, when considerable sums of money may depend upon the decision, adds a new dimension to the theory.

The account of the turn-around of Japanese industry following the Second World War, largely because of the implementation of statistical techniques introduced by the American, Dr William Edwards Deming, is in itself an excellent example of the power of statistical

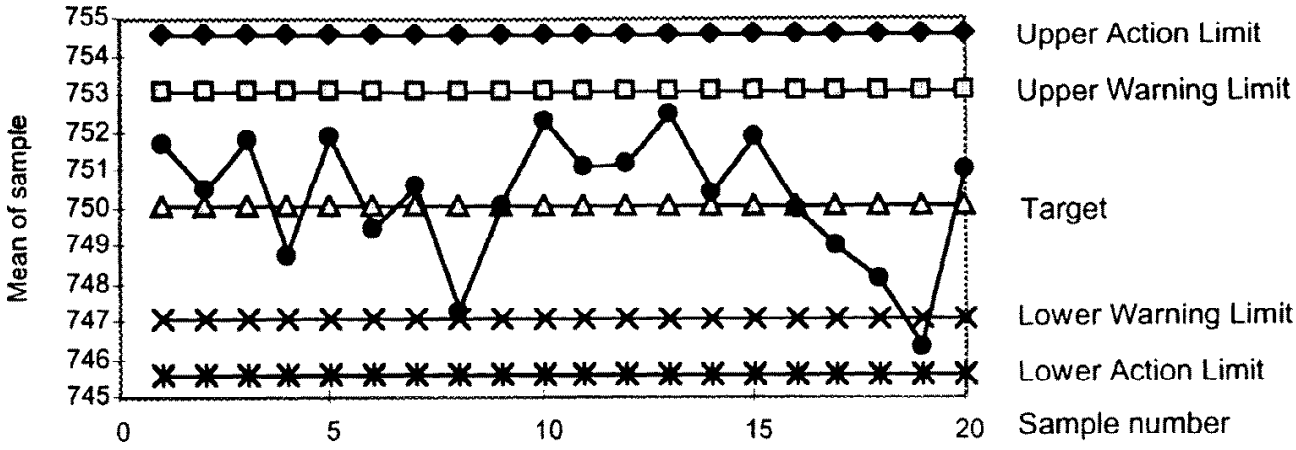

Fig 2. Control chart for means

techniques. Yet how many teachers of statistics or even managers in industry know anything about Dr Deming? Certainly, his name only really registered with me when I had come across it several times: occasionally from people in industry but, more frequently, from reading the books about industrial quality control. Mary Walton's book "The Deming Management Method" (Walton, 1992) gives a fascinating account of Dr Deming's life as well as an overview of his philosophy on the integration of statistical techniques into management. The British Deming Association (see Web site in references) can provide further materials and information to teachers.

The use of (Shewbart) control charts for monitoring the mean of samples taken from the production line provides numerous examples on the Normal distribution. Figure 2 shows a simple example of such a chart. (The process seems reasonably under control!) Some of the extra warning and action conditions, such as consecutive values on the same side of the mean, provide further examples on the binomial distribution. The equivalent charts for the number of defects in an item provide examples of the use of the Poisson distribution.

I had read many times that the exponential distribution provided a good model for time to failure, but it was when I had heard this from people actually using it that I could tell my pupils about it with some degree of conviction.

◆SCHOOL AND WORK◆

The collection of real data by experiments or surveys is now a part of most school-level courses in mathematics and statistics. The pupils can get the feel for some of the practical difficulties from their own exercises. However, if something goes wrong it usually doesn't matter too much ... even for the assessment. On the other hand, in the outside world large sums of money and/or people's jobs depend upon the right data being collected and sufficient of it. For example, a firm considering manufacturing larger "coasters", designed for mugs rather than cups, needs to have a good idea of the potential market for these items and also the most popular shapes and designs to use. Look out for the product coming on the market ... my pupils are!

It is obvious that a key way to reduce errors in an experiment, or a survey, is usually to increase the number of experiments which are performed. In school contexts that can usually be done without too much cost in time or money. However, if the experiment is being done by a pharmaceutical firm which is developing treatments for animals, and the test involves killing the animal to assess levels of toxicity, the costs are high, and correctly designing the experiment will minimise the financial cost and the cost in numbers of animals killed. Similarly, if each experiment takes about a week and the facilities in the laboratory mean that only one experiment may be performed at a time, it is extremely important that the number of experiments is minimised, whilst providing the information required.

◆MAKING CONTACTS◆ FOR YOURSELF

I found the people whom I visited extremely helpful and patient with my ignorance. Again and again I was impressed by their competence and intuitive feel for the situations in which they were working. One such person, whose decisions on quality control influenced a large number of jobs and also had implications for vast sums

of money, told me several times that he knew “naff all about statistics” (i.e. almost nothing) but in fact he had a tremendous intuitive grasp of confidence intervals based on small samples from an exponential distribution. Having once made the contacts, I have generally felt that I could go back to the people if necessary ... and have done so already on one or two occasions.

My contacts with industry came through “friends of friends”, parents of pupils, or simply by telephoning local firms. I have not mentioned any names in this article because I had not cleared this with the firms concerned.

In most cases, I made the visits to industrial statisticians on my own. The main reason for this was that it kept the arrangements as simple as possible. In some cases went with a colleague. Having made an initial visit, then were some places where I felt that it was worth arranging a follow-up visit with colleagues and/or pupils. In on case, I asked the director of a local market research firm to come into school to speak to a class. Often the “story which the statistician had to tell was fascinating, but there was nothing of interest to see and so I felt that the best way to use the information was for me to retell it at an appropriate time in a lesson rather than arrange for pupils to visit the person.

As well as making visits to industry it is interesting to read something about the applications of statistics in the “real world”. Two books which I have enjoyed are “Statistics: A Guide to the Unknown” (Tanur *et al.*, 1989) and “The Statistical Consultant” (Hand and Everitt, 1987). In a similar vein, I appreciated the 1993 article in this journal by Maria Darma and Rosie Poultney, from the Rothamsted Experimental Station, on their work in the Falkland Islands and in Thailand, and I for one would be very happy to read more such articles in “Teaching Statistics

One other possibility, which certainly deserves a mention, is to visit the local meetings of the *Royal Statistical Society* (Web site given in references), or the corresponding national organisation in other countries. It is not usually necessary to be a member of the society in order to attend such meetings. The subject of the talk will often be the work of a statistician. Some of the people attending the meeting will almost certainly be from industry and so there is the possibility of making useful contacts before and after the meetings.

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Web sites:

British Deming Association:
http://www.deming.org.uk
Royal Statistical Society:
http://www.rss.org.uk