Teaching Statistics in Pre-clinical and Pharmaceutical Departments

Kerstin Wiklander
Department of Mathematical Statistics
Chalmers University of Technology and Göteborg University
SE-412 96 Göteborg, Sweden
E-mail: kerstin@math.chalmers.se

1. Introduction

In this article I will describe some personal reflections and experiences from courses given at the university as well as in the industry. Thus, I will not comment or give reviews on other articles in this area. The experiences I have obtained come from courses held for students in medicine, science and technology and for people in the industry. For several years I have worked in the pharmaceutical industry. A great deal of my working time consisted of collaboration with researchers from pre-clinical and pharmaceutical departments as well as giving courses in statistics within the company. These years have given me many useful experiences and insights in problems, applications and needs of the practicians. Some ideas in this article are also the results from a pedagogical project with the purpose of making the statistical education of engineers more interesting and applied.

2. Aims and goals

Some fundamental aims of a course for non-statisticians are to increase the consciousness about statistics and to attain improved understanding for variation and how to deal with it. Besides motivating the usefulness of statistics, it is also important to bring knowledge in fundamental concepts, ideas and statistical methods.

Some concrete goals could be to give the students ability of the following types:

- Recognise typical problems and formulate them in statistical terms.
- Apply suitable models.
- Apply some statistical tools in form of standard analyses.
- Draw correct conclusions from the statistical results.
- Describe the results in a clear way referring to the presentation of the problem.
- Be encouraged to use statistical thinking and philosophy.

After attending a course, the participants must be able to solve simple problems on their own. Instead of calculating mean values and standard deviations and then only compare means (which unfortunately is quite common), they should be able to do a proper statistical analysis and take decisions on the basis of the results. The contents of a course should bring to them the possibility to draw conclusions and, where appropriate, to generalise with a known risk of error. Thus, they should learn to deal with the experimental error and understand and control at least the Type I error.

In addition to the fundamental parts, it is also valuable to be able to recognise certain types of more difficult problems, to be trained to think in models and to be introduced to statistical programs. Let planning be natural. It is an undervalued part of statistics and is at least as important as other phases of the statistical work.

In industry, a course gives a valuable opportunity to establish contacts between statisticians and the course participants, that is, professionals in other disciplines.

3. Problems and difficulties

Statistics is a subject, that even most statisticians find difficult! In a short course, it is not easy to have time for all the aspects that are needed to be able to use statistics in real life. Real world applications often involve quite complex situations. We can not overlook the crude reality; it is much more complicated than any model. In the academic world, it is possible to first find the theory and afterwards search for applications to the results. From a practician's point of view, one has to start from the other end of the line and focus on the problem. However, it is not always easy to find statistical solutions to their problems, where practical restrictions put an end to many constructive ideas.

Often, I have met students with other main subjects than statistics having different backgrounds, knowledge and training. It is difficult to overcome and adjust for this in the short time a course is hold. On the other hand, trying to seek sympathy from the student by simplifying everything is dangerous. If the problems are not recognisable, the confidence for statistics will be damaged. Another problem is lack of time to give the logical structure and the right feeling for this complex subject.

There is a well-known problem that students do not always put knowledge obtained from courses into practice. They seldom recognise the situations when statistics would offer a natural tool even though the need is great. One of the reasons for this is that we often underestimate the need of that type of training.
In the exercises of most textbooks, the design, sampling method and model are usually already given. The remaining task is then to pick a method, do the calculations and to interpret the results. Then, a great part of the problem is already solved in advance.

4. Line of action, some suggestions

It is not easy in a short course to provide enough knowledge and skill to be able to use a good design, choose a proper model and method and draw correct conclusions from the results. After working in the industry, I have noted some successful features. Some steps to approach the problems in order to meet the aims could be the following.

Tailor-made courses

A great advantage is to use material adjusted for the students and developed in co-operation with persons responsible for the education. These ones must give information about the knowledge and experiences the students possess at the time for the course. One should aim at using as much as possible in the framework of such applications that are well known to the students. The best is to use tailor-made courses, where the students recognise the applications and the participants from industry their own daily work and problems. New terminology must be held to a minimum, not in the descriptions of the applications, merely connected to the statistics. A lot of questions concerning dose effect, plasma concentrations, determination of half-life, in-vitro screening methods and suchlike may be used. They can in a natural way illustrate descriptive statistics, distributions, inference, experimental design etc. Such courses need a lot of resources and take a long time to develop. Naturally, it includes collaboration with other disciplines, which also may be hard (but also interesting and instructive) for a person specialised in statistics only. Typical problems and situations in a possible future profession, at least taken from relevant articles, may serve to recognise the need of statistical tools to solve

these problems. Of course, the best way to create motivation is, if it is possible, to use examples and applications from the students' everyday life.

Practice

During my time in the industry, I had the opportunity to let the participants practice at once or very soon after that new theory and concepts was introduced. This was received with approval of the participants. Together with the interactive training, some statistical software can be introduced, though this is not easily done in large classes. However, often there are computers with some statistical software available and exercises as homework could at least be given. This should be followed up with discussions and interpretations of the results.

Laboratory experiment

It should be avoided to give answers before the students are conscious of and have formulated the question. It is not easy to realise all obstacles and difficulties an experiment might offer only from reading in books. For future needs, it is quite instructive and important to distinguish between an exercise in a textbook and a problem from reality, where nothing is given in advance. With an own experiment, no matter how simple and "home-made" it may be, the students are activated. Also, they can try all phases in an experimental process, such as to formulate the problem, plan, choose a good design, pick variables easy to measure and reflecting the problem, consider sampling, models and methods, perform, analyse, draw conclusions and report. This may give them a deeper understanding and experiences and encourage their own statistical line of thoughts. After the experiences from some own work, questions and communication come more natural. Also, there is a natural opportunity to emphasise the importance of planning. An incorrect analysis can be re-analysed whereas an incorrect or messy design inevitably brings problems.

In general

Nowadays there are a lot of statistical packages widely spread in industry from which large amounts of results are produced. But how are these treated? It is important to instruct the students to be cautious in the use of statistics and emphasise that it is a serious error to use an incorrect method. Inviolable results require appropriate models and correct methods. The world is full of p-values and stars, but it is important to be able to distinguish between statistical and practical significance. It is a good chance to motivate the advantage of estimation to p-values. Also, in the computer age it is appropriate to point out the problem of multiplicity.

5. Some final comments

Courses at the university meet the difficulty that it is not obvious what the students will do after the education. They might not have made their choice of profession at that time, but if so, they seldom have the professional experience yet and therefore they may have difficulties to recognise typical situations. Thus, there is the dilemma that statistics is needed early to be able to *recognise* applications during the education. At the same time, statistics is needed later for *use* in relevant applications and examples of earlier courses. A solution to this dilemma in a long education could be to have a short introductory and applied course early, which would help and enable the student to interpret information in a statistical way, for example from articles. Late in the education, a more substantial course would suite, giving knowledge to enable the student to use statistics in their own research. Meantime, the contents from the first course have had some time to mature.

It is worth aiming at a suitable mixture of practical applications and major theoretical results to avoid reducing a course to merely a statistical manual with a very restricted insight into the subject. Thus, one should not yield to the temptation of entirely avoiding mathematics.

Finally, a course in statistics may be used not only to teach a lot of methods. It is a good opportunity to bring out statistical thinking, give a feeling for the subject and the advantages of using it. It could be a possibility to give good publicity for the subject and show the benefits and values of statistics.

SUMMARY

Giving a short course for non-statisticians is a challenge. Students, who are likely to have different previous training in mathematics and statistics, shall together learn statistical concepts, theory and techniques. At the same time, it is an opportunity to give the students a constructive attitude to the subject.

Some examples of successful features in a course could be to use material adjusted to the students. Taylor-made courses require a lot of preparation, but usually the students receive them positively. It is also an advantage to practice very soon after new theory has been introduced, preferably with computers and in small groups. Also, let the students themselves experience some parts of statistics by home-made and practical experiments instead of leaving them with passive lectures and book-studies. Follow-up discussions are usually very fruitful and constructive, since the students by that time are motivated and more conscious about the problems.