CHANGING THE COURSE: FROM BORING NUMERACY TO INSPIRING LITERACY

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The course "Introduction to Statistics" was run at the University of Helsinki for nearly 40 years basically unchanged. I experienced it as a student in 1990 and shared the common impression: the course was boring, out of context and seriously out of date with its focus on mechanical calculations. Nearly 20 years later, in 2008, I became the responsible teacher of the course. The bad reputation of the course, together with 300 uninterested students provided me with a challenging opportunity. I changed the course quite completely: the contents, the focus, and the pedagogical practices. Instead of mathematical numeracy it now focuses on statistical literacy. As a result, the course has become popular, attracting 600 interested students from all over the University. In this paper, I reflect on my experiences with this course.

INTRODUCTION

The role of statistics has become increasingly evident and important in the modern society. Statistical methods of collecting, measuring, visualizing and analyzing data are more or less related to the current practice of all fields. As a consequence, university students should know at least something about statistics, and preferably much more than just "something". The details of this recommendation (or requirement) depend on the field of study and may vary a lot. Hence it is reasonable to offer different courses of (introductory) statistics to students of social sciences and say, biosciences. In any case, an introductory course of statistics is often the first (and too often the last) course of statistics for most university students in all possible fields.

In this paper, I reflect on my experiences with an introductory course of statistics offered primarily to the students of social sciences. I show why and how I changed the course completely.

Historical Background

The course ``*Introduction to Statistics''* has a long tradition at the University of Helsinki, as it has been taught at the Faculty of Social Sciences since the mid-1960s. The course has been primarily offered to the students of social sciences (sociology, social policy, social psychology, economics etc.). For most of them, the course has been a compulsory part of their Bachelor's degree, typically taken during the first year of study.

Nearly 50 years ago, the course must have been a success with its focus on the manual calculations that were required to obtain test statistics or any numerical summaries. However, as the idea and implementation of the course did not change much over the years (or decades), a discrepancy between the course and the surrounding world became more and more evident. As a consequence, increasing number of students (including myself in 1990) felt that the course was boring and seriously out of date. The infrequent "real-world" examples from the Olympics of the 1960s did not actually motivate for further studies of statistics. For thousands of students, the first impressions of statistics as a discipline were based on that course, so it was quite obvious that the image and reputation of statistics were not very glamorous for a long time.

Usually, the course was organized on each semester. In the end of the 1990s there were alternative implementations that were partially based on the favorite text book by Freedman et al (1991), emphasizing connections to real-world problems. However, the focus was still too much on the formulas and calculations. More radical actions were needed to change the course.

FACING THE CHALLENGE

In 2008, I faced the greatest pedagogical challenge of my career, when I was appointed the responsible teacher of the introductory course. All the previous teachers had retired and "suddenly" it was necessary to find somebody to take charge of the course. In that phase, the course had a horrible reputation of being unrelated and old-fashioned, and it was still compulsory for about 300 more or less reluctant students of social sciences annually.

Meanwhile, I had become a university lecturer and an applied statistician, very excited about statistics and its diverse applications and possibilities. I had forgotten the unpleasant first impression of the introductory course that I had experienced as a student nearly 20 years earlier. Until 2008, my own teaching experiences had consisted of applied courses on data analysis, linear models and multivariate methods. I had never taught the introductory topics before. For me, it was self-evident that I would not continue the old traditions. The need to change the course was inevitable, providing me with a challenging opportunity to create a modern and an inspiring introductory course. At present I am happy to say that I succeeded.

What to Change and How?

Basically, I had to change almost everything: the contents, the focus, the schedules, and the pedagogical practices. One rare thing that remained unchanged was the name of the course, although I saw the risk of the old image haunting. However, I was quite sure from the beginning that even the reputation would change, at least in the long run. I was used to having nice teaching experiences before, especially with non-statisticians, so I felt convinced that I could succeed with the introductory course as well.

First, I needed to state certain goals for the new course. As the course was still offered primarily to the students of social sciences, I decided to tune the focus and create connections to other disciplines so that those students would find the course interesting and useful. I wanted to stress that instead of representing some unrelated calculations, statistics is strongly related to the students' own fields of study and somehow intertwined in every single research process of social sciences, beginning from the data collection and measurement, proceeding through the data analyses, up to visualizing and presenting the findings, drawing conclusions and communicating the results. That was the big idea that would constitute the main thread of my course.

I formulated the primary goals in a form of questions that the students should be ready to answer after the course. The questions would also give an idea of the course in general. They were of the following type:

- How to measure abstract multidimensional social phenomena?
- What kind of data to collect, from whom, from where, and how?
- How to handle the issues of validity and reliability in questionnaires?
- What do we mean with concepts of mean or variation and dependence?
- What are the effects of randomness and chance to statistical research?
- What is actually assumed when applying statistical analysis methods?
- How to draw reliable statistical and substantial conclusions?
- How to read and interpret statistical results, graphs and tables?
- What is the role of the computer and statistical software?
- How to (not) lie with statistics?

Remembering that this would be an introductory course, it was obvious that none of these topics would be covered deeply. Instead, the aim should be to cover a meaningful variety of topics, all strongly connected to real-world applications, especially in the fields of the social sciences.

Perhaps the most important overall goal would be a hard one: to affect the general attitudes towards the course and even towards statistics in general. My desire would also be to motivate and encourage the students for further studies of statistics, instead of letting them to lose their motivation on their very first course.

CHANGING THE COURSE, PART 1

Luckily I could plan and proceed without restrictions. Based on the preliminary ideas and questions listed above, I sketched ten themes that would form the core structure of the course. In addition, to allow some extra flexibility, I split the course in two distinct parts, namely Part 1 and Part 2, of five themes each. Based on my earlier experience, I felt that a clear structure was important, because it would imply a clear schedule and clear objectives for the course. Hence, Themes 1—5 consist of collecting, measuring, describing, and presenting data as follows:

- Theme 1: Statistics and survey research
- Theme 2: Measurement in social sciences
- Theme 3: Data collection, graphs and statistics
- Theme 4: Variation and dependence
- Theme 5: Cross tabulation

Part 1 is very descriptive in nature and differs substantially from the earlier course in all respects. About 50 % of the content (most of the Themes 1—3), is allocated for data collection and measurement, especially in the survey research. Questionnaires of real studies are used to learn the statistical key issues of survey measurement—important topics that may be skipped altogether on many statistics courses. Respectively, real survey data sets are used to study graphs like box plot, histogram, bar and pie charts as well as the most typical univariate and bivariate statistics.

Instead of calculations, the focus is always on interpreting and understanding the numbers and statistics, together with useful graphs. For example, mechanical calculation of the arithmetic mean with some small artificial data set is not exercised at all, simply because it is far from reality and hence completely useless. It is much more important to understand the assumptions behind the mean, its pitfalls and alternatives. This understanding is best achieved through demonstrations with real data sets, letting the computer and statistical software to take care of the calculations.

A similar principle applies to Theme 4, which introduces the concepts of scatter plot, regression line and the correlation, again very descriptively and visually. Theme 5 expands the topic of dependence to discrete variables. None of these topics involve calculations. Instead, they include several examples using real data sets and critical discussion about the assumptions and interpretations. Together with the various different graphs that are embedded in each theme, all this highlights statistical literacy instead of mathematical numeracy. The culmination of Part 1 is the "Rosling lecture", where we watch and discuss a couple of Hans Rosling's famous videos of the importance of statistics in understanding our society and the global world (www.gapminder.org).

CHANGING THE COURSE, PART 2

Themes 6—10 make up Part 2, which does not seem to differ so much from typical introductory courses, when looking at the headings:

- Theme 6: Chance, randomness, and probability
- Theme 7: Binomial and normal distributions
- Theme 8: Parameter estimation and confidence intervals
- Theme 9: Hypothesis testing and the cult of statistical significance
- Theme 10: Regression analysis and one-way ANOVA

Although Part 2 is mathematically a bit more demanding, it is nevertheless built on similar principles as Part 1. The main goal of Part 2 is to get a grasp of fundamental statistical methods (like regression analysis) needed in the social sciences. Therefore it is necessary to familiarize the students with the basic concepts and principles of probability and statistical inference, including confidence intervals and a rather critical view of hypothesis testing.

As many students of this course have a quite weak mathematical background, it is not the point or aim to practice too much mathematical statistics. It is still important to understand certain essential concepts like probability distribution and parameter estimation as well as the general role of randomness in statistical research. Therefore, a small amount of manual calculations is still part of the course, but it is supported with readily worked examples with real data sets.

However, in certain point of Theme 9, the calculations would get too complicated for this course, and so the rest of the course focuses on discussing and interpreting the computer outputs of the methods, similarly as in Part 1. The difference is that the topics of the preceding Themes 6—8 help to deepen the level of the discussion with more diverse points of view.

For example, the regression line, which is introduced descriptively in Part 1, without any formulas, is re-considered in Part 2 as an example of a linear statistical model, where some

parameters are estimated based on certain assumptions on the probability distribution. It would be impossible to discuss these topics in any detail without first establishing a set of proper concepts related to probability distributions and parameter estimation. However, it is easier to proceed in Part 2, when some of the topics have been introduced elementarily or intuitively in Part 1.

For motivational purposes, several more advanced methods that are important for social sciences (like factor analysis, structural equation models, logistic regression analysis or two-way ANOVA), are mentioned during the course, with a sincere hope that the students would be interested to continue their statistics studies after the introductory course.

CHANGING THE PEDAGOGICAL PRACTICES

The ideas and principles of constructive alignment (Biggs 2003) were helpful in planning the renovation of the course. Because of the large volume of the course, the practices must be explicit and as simple as possible. In the end, that was fairly easy to achieve, as the core structure of two parts with ten themes formed a solid base for clear schedules but also for other pedagogical practices.

Each theme corresponds to one week of study. It begins on Thursday (8:15 am) with a lecture (of 90 minutes), where the topics of the theme are presented and discussed. The students get the material in PDF form from the course homepage in advance, so they can complete it, e.g., by highlighting and adding their own notes. The weekly material includes about 20 lecture slides and a set of exercises to be done either individually or together with other students. We do not follow any particular text book.

In Part 2, there are also a total of four workshops (of 90 minutes each) on Monday and Tuesday, where the participants may ask any questions and get technical and other support for completing the exercises. Each workshop is supervised by two of the four course assistants (major students in statistics or mathematics), whom I recruit to the course. Although the course is compulsory for many students, all activities such as attending the workshops or the lectures or doing the exercises are completely voluntary, without any administration or control. The students are simply encouraged to be as active and studious as possible. I like to invest maximal resources for supporting the learning and put only minimal resources for the course administration.

The study week ends on Wednesday with another lecture (again 8:15 am) that is used exclusively for summarizing and discussing the solutions to the weekly exercises. It is like another viewpoint to the theme of the week, where the topics are revised from an alternative angle. It was one of my first decisions to "sacrifice" the other lecture of the week for this summary purpose, as I felt that otherwise there would be too much material and not enough time for learning it. My aim for one study week was to have less content better learned before approaching to a new theme. Nowadays the summary lectures are automatically recorded on video and they are available to the students on the university intranet. The original reason for this was a too small lecture hall (enough large ones are hard to find), but as the students found the videos helpful also in revising the topics, it became the usual procedure.

Part 1 and Part 2 are graded separately, based on their own exams. One week before an exam, four extra workshops (of 90 minutes each) are arranged for revising any topics of that part. Following the alignment principle (Biggs 2003), the exams constitute a part of learning on the course. They consist of exercises that are quite similar with the exercises during the course. In Part 1 exam, no calculations are needed, whereas in Part 2, some may be needed although not required to pass the course. The focus is always on understanding the concepts and interpreting the graphs, tables, and computer outputs.

RESULTS

Changing the course has clearly had notable implications that have been easy to observe. Before I started with the course, students continuously complained about the course to the Faculty. Since I started, the complaints ended. Instead, I started to get spontaneous student feedback, both face-to-face and in email, telling me about meaningful learning experiences, growing enthusiasm and interest towards the topics of the course and statistical methods in general. For example, some students have told me (long after they have been on my course) that they had never considered

using quantitative methods in their Master's or Doctoral theses, but on my course they had been inspired to change their mindsets in this respect.

CONCLUSION

I would conclude that the course has become recognized and even popular in the Faculty and well known even university-wide due to three important changes that I have made while planning and teaching the course in the past six years.

Firstly, instead of focusing on mathematical numeracy, the course now focuses strongly on statistical literacy using real, interesting research data and other relevant material. This is perhaps the most important single reason for the success of the course, as it clearly shows how statistics is needed and used in various contexts and applications of social sciences.

Secondly, instead of trying to cover too many topics without a clear distinction between the essential and additional ones, the course now focuses on the most important topics only, therefore giving the students more time for learning the fundamentals properly.

Thirdly, instead of a wide and vague collection of topics scattered along the semester, the course now has a clear structure and schedule. It consists of two parts with ten concise themes that are worked out in a reasonable weekly pace, allowing enough time for critical discussion.

In this paper, I have reflected on my personal experiences of changing and reforming the largest introductory course of statistics at the University of Helsinki. Overall, the results have been extremely positive and encouraging. Based on the experience of nine iterations and the feedback from the students, course assistants, and colleagues, the structure, the content, and the schedule of the course as well as the workload for the lecturer, course assistants and the students, seem to be in a good balance.

There are several possible directions for future research and development of the introductory course. One would be to study the students' approaches to learning and make international comparisons (Chiesi et al 2013). The increasing number of laptop computers and smartphones among the students could stimulate interesting research on the effects of statistical software or online participation platforms on the course.

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