TEACHING STATISTICS IN A CRITICAL WAY: HISTORICAL, PHILOSOPHICAL AND POLITICAL ASPECTS OF STATISTICS

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In this paper we sketch the history and the philosophy of statistics and probability theory and the connections to its political aspects. Knowledge of the cultural embeddedness of statistics and probability theory is an added value in the teaching thereof. The use of statistics and probability is a phenomenon with which everyone is confronted on a daily basis. Beside literacy, numeracy is an important challenge for education. In order to succeed in this task, the traditional curriculum (technique-oriented and individual, competition-oriented) will need to be sacrificed for a curriculum in which there is room for the cultural aspects of statistics and probability theory. For this purpose, cooperative learning is a didactic entry which is suitable for interaction and critical input of pupils.

INTRODUCTION

Looking at the history of statistics, one can show the growing importance of statistics in social sciences and in society in general. Understanding statistical representations, being able to interpret graphs or to give meaning to information in figures today are part of the skills that are generally assumed. Education, and particularly education in probability and statistics, face the challenge of helping to develop this competence. If education wishes to take up part of the responsibility to bring about a democratic state in which all have access to basic information like the media, then the development of a working knowledge of statistics and probability should form part of the curriculum. Hence, we are now in a period of trying to teach statistics to all. We shall argue that we have to do this in an accessible and critical way. In order to do so, we have to integrate the history of statistics, the social relevance, the hidden values and the political meaning of (the use of) statistics. We therefore look at the historical, philosophical and political aspects of statistics before returning to the question of how these elements can contribute to the critical teaching of statistics.

HISTORY

The scientific and methodological bases of contemporary descriptive and mathematical statistics lie in the selfsame intellectual circles as those of the new natural sciences, with whom early statisticians (like Descartes) had in common their objectives (quantitative descriptions, tracing patterns) and methods (observation, use of mathematics) (Leti, 2000, pp. 201-202). From a historical point of view, the German *Staatenkunde*, the English political arithmetic and the French probability theory come together in statistics. Methodologically, statistics is fed by the French census.

That these elements now converge in ‘statistics’ is the result of a historic process of integration and competition and of consecutive shifts in meaning. The nineteenth century was a hinge century for this. In encyclopedias and dictionaries in the beginning of the nineteenth century, statistics was defined as *Staatenkunde*, a narrative and administrative discipline meant to describe the country and society, to deduce the ‘strength’ of a state and to ground the country’s government on. In the first half of the nineteenth century, statistics evolved in the direction of political arithmetic. Without leaving it behind as administrative practice, statistics around 1850 increasingly came to be understood as a science which deduced patterns from a great many quantifiable observations about society. In this sense, statistics was first and foremost a social statistics. By integrating probability calculus, the possibility was created to also make universal statements on the basis of a limited number of observations. Originally, this approach did not flourish in statistics (Stamhuis, 1992, p. 145). Therefore, up until the third quarter of the nineteenth century, statistics was primarily descriptive. In the beginning of the twentieth century, mathematical statistics developed, spurred on by developments in other sciences (for example Pearson's contribution from eugenetics and biometrics), to a fully-fledged branch of statistics (Desrosières, 1998, p. 12). So around 1900, encyclopedias characterised statistics as both a descriptive and a mathematical discipline. Moreover, it was at this point no longer exclusively related to political and social phenomena, but it was also applied in the natural sciences.

The evolution of the concept of statistics was a gradual process, which was not without discussion. In nineteenth-century Belgium, for example, statistics was principally *Staatenkundige* official statistics. The other interpretations of statistics had difficulty to gain recognition. The shifts in the concept of statistics and the integration of new meanings did not, however, imply that old notions had vanished. For a large part of the nineteenth century, the three meanings of statistics – *Staatenkunde*, social statistics, mathematical statistics – existed side by side. Sometimes they even coincided. Adolphe Quetelet (1796-1874), for instance, was at the same time state statistician, social scientist and probability theorist. These developments reverberated in statistics education. The predominance of official statistics – in Belgium and elsewhere – in the nineteenth century to a large extent determined the academic position of statistics. As an administrative discipline, statistics was originally taught in Law faculties (Ottaviani, 1991, p. 245). Until way into the nineteenth century, most statisticians in Belgium were jurists. From the very foundation of the State Universities of Ghent and Liège in 1817, the subject of statistics was compulsory for those reading for a degree in Law. Lecturers were regularly recruited from Germany, so that they were familiar with descriptive *Staatenkunde*. Via a primarily historical perspective, the lectures provided an insight into the political organisation, the geographic development, the agriculture, the economy and the population of the country. Beside the link between statistics and law, a strong link thus existed between statistics and history (Harsin, 1966, p. 169). This connection, like the increasing use of statistics to describe a country's economics and politics, can explain why in the Arts faculty too, for many decades, there were experts in statistics. Between 1835 and 1849, statistics in Belgium was taught in this faculty to their own students and to law students (Ottaviani, 1991, p. 246). In those days, higher education was far from oblivious to new influences in statistics – social statistics and probability calculation. Future engineers at the Ecoles du génie and mathematicians and physicists in the Science faculties were taught social arithmetic, sometimes combined with probability calculation.

In 1849, *Staatenkunde* statistics was eliminated from the list of compulsory subjects in the Arts and Law faculties of the state universities (and this until 1893). Even the course 'social arithmetic' for engineers disappeared. This may have been connected to the rising criticism (for example in Parliament) of the expensive official statistics, which to government were of little use and which were shifting towards the social sciences. That probability calculus was preserved as a subject in the Science faculties in 1849 may have been due to the fact that in this faculty the link to statistics was not made. Where statistics and probability were connected, it often led to criticism. It was not until the twentieth century that a change set in and that statistics as a descriptive and mathematical discipline and as a method found its way into the curricula at various faculties. Statistics disappeared from the curricula in the Faculties of Arts and Philosophy and Law. On the one hand, statistics was taught as a methodology to future social scientists, psychologists and economists; on the other hand, it became the subject of a science. In both cases, the curricula paid a lot of attention to probability theory.

PHILOSOPHY

During the nineteenth century, official *Staatenkunde* statistics determined how 'true knowledge' was defined (and produced) and how 'reality' was grasped. This heavily influenced statistical methodology. In the *Staatenkunde* version of statistics, only exhaustive measurements or descriptions could result in 'true knowledge' or in the 'faithful' representation of 'reality.' This changed through the acceptance and the integration of political arithmetic and probability theory in statistics. Sample surveys were acknowledged as a method to attain 'reliable' knowledge, the underlying idea being that even partial observations could bring about 'true' or 'objective knowledge.'

The transfer in significance and application of statistics is also related to a scientific-philosophical and, more specifically, an epistemological notion. The scientific optimism within the natural sciences spread to the social sciences. A new vision of the world sprang up. The way in which one would gain knowledge of the world was no longer considered “as a shadow of an ideal world but as a reality which had to be fully explored in total freedom and allow man to draw every possible advantage” (Leti, 2000, p. 202). Even within social sciences, one would discover the underlying laws through quantitative description. The quest for the invariable and the universal prevailed over a phenomenological knowledge of the world. A central question hereby is which subjects were to become known and in what way. These questions lead us back to the beginning of the seventeenth century. It was not only Galileo who thought that “the book of nature is written in the language of mathematics.” Descartes also saw mathematics both as the language in and the method through which our knowledge about nature is best expressed (Descartes, 1966). This philosophical idea became the core of the modern conception of science and was further generalised from then. Moreover, the idea of the mathematisation of the world, i.e., to grasp it with absolute certainty and hence to the highest degree of objectivity, became a goal not only for the so-called ‘hard sciences’ but also for humanities and social (‘soft’) sciences. Social sciences lack correct and significant basic principles due to the immense complexity of the phenomena that they wish to study. The failure to penetrate social sciences by the mathematical, deductive method (the method of reasoning from axioms) contributed to the development of the mathematical theories of statistics and probability by social scientists (Leti, 2000, p. 190). In fact, the statistical approach to a problem can be considered to be a confession of ignorance. Where mathematics has to do with certainty, statistics is a way to handle uncertainty. Whereas the former predicts what must happen in an individual case, the latter can tell us what happens to large groups but does not provide definite predictions about any one given case (Kline, 1985, p. 501).

Around the middle of the nineteenth century, statistics for the first time, by integrating political arithmetic and probability, made it possible to make calculations on the data gathered. William Petty (1623-1685), who gave the name of ‘Political Arithmetic’ to the infant science of statistics, insisted that social sciences must become quantitative without having mathematical methods for extracting significant implications from the data. In the early nineteenth century, this idea was absent from statistics, which at the time was a purely political discipline. Around 1830, Quetelet revived the basic thought that statistical methods might produce significant laws for the social sciences as the way to reach a higher degree of objectivity. More specifically, political arithmetic and probability allowed statistics to detect causal relations between variables. They made it equally possible to generate universalising knowledge on the basis of partial observations and were an instrument to test the ‘reliability’ of observations and to come to more ‘objective’ knowledge. Initially, these insights did not find acceptance in the *Staatenkundige* official statistics, but rather in social sciences. In statistics they were at the root of social statistics, which had as its object of study not so much the state, but the autonomous social body. While Auguste Comte objected to this procedure, Quetelet for one introduced the statistical method in his social-scientific research. From the late 1820s, he was investigating relations between variables in people and society. In the late 1820s, he discovered a great regularity in physical, intellectual and ‘moral’ human characteristics, which were observed in great quantities. He grounded a new science on this, which he originally called ‘social mechanics’ and from 1835 onward ‘social physics’ (Quetelet, 1835). The name of this new ‘science’ was not chosen by accident. Social physics emulated natural sciences. Just as physics looked for laws that ruled nature, social statistics and particularly social physics was to uncover laws in society (Leti, 2000, p. 198). Statistics only allowed partial observations when around 1900 the notion of ‘representativeness’ and the sample survey won acceptance, a development fostered by the work of Anders Kiaer (Bulmer, Bales and Sklar, 1991). Because of this, mathematical statistics could grow to full stature. As a full branch of statistics and as a mathematical discipline, mathematical statistics formulates conclusions about populations on the basis of sample surveys. This branch of statistics has integrated probability calculation to the full, especially as a method to test the validity of the conclusions. Apart from being a science in itself, statistics in this period fully became a method, applied in other sciences and even in (at first sight) non-scientific branches of life. In a wide range of social and natural sciences – like biology, psychology, economics, sociology and physics – and humanities, the application of statistics led to new norms by which to measure ‘objectivity.’

POLITICS

A first link between politics and statistics is related to the origin of statistics itself. Both *Staatenkunde* and political arithmetic were related to the 'art of government.' *Staatenkunde* found its *raison d'être* in describing countries for the sake of government. Petty defined political arithmetic as "the art of reasoning by figures upon things relating to the government." In the nineteenth century, official statistics in particularl was an instrument to inform politicians and to guide policy making and broader governmental tasks. This purpose had less to do with the use of statistics as a method to gain objective knowledge. Instead, the use of statistics had rather specific political, if not, party political purposes.

A second link between politics and statistics is (scientific-)philosophical in nature and gives the term 'political' a broader meaning. Political refers to the fact that the making of a choice is socially relevant. In this sense, politics forms part of scientific activity (Latour, 1999). To the production of science, the choice of method cannot but be central and this choice impacts on the topics studied. An in-depth interview will generate knowledge of other things than a statistical approach does. Both approaches attach their own set of conditions (constraints) to the topic under scrutiny. And what about so-called objective knowledge? Even here a choice, a perspective, a way in which the world becomes known comes into play. Opting for a method that is thought to guarantee the highest degree of certainty and objectivity inevitably brings with it constraints on the objects of knowledge (e.g., the reduction of a complex problem to a variety of variables, the selection of the variables, correlations…). Bruno Latour (1991, p. 14) and Isabelle Stengers (1993, p. 101) prefer to speak about production of truth (*faitiche expérimental*). 'Objective' truth is 'produced' truth in the sense that the facts are constructed so as to give birth to objectivity and universality. If indeed this is so, if the method influences the objects that are knowable, if perhaps in a way it even actually 'produces' these objects, then we could go on to claim that it might very well produce objective knowledge, but definitely not *neutral* knowledge. It is not neutral in that sciences (even statistics) are embedded in the social. Moreover, it is not neutral in the sense that the way in which we epistemize the world always includes a perspective, even if it is that particular one that tries to grasp the world with absolute certainty and objectivity. Using whatever method involves a choice of a specific method. Hence, it always has a social dimension and therefore we can indeed call such a choice a political act (François and De Sutter, 2005). Likewise, if we are using (inferential) statistics as a method, we will need to persuade ourselves that the approach of a socially complex phenomenon necessarily demands the stripping of all variables of the phenomenon until we get to the sole constant about which we wish to collect statistical knowledge. In this way, we try to generate and to predict laws on the level of complex social phenomena. A statistical approach will invariably be a certain fragmented approach of an issue and in this respect will always 'remain a shadow of the ideal world.' Over-simplified scientific optimism thus takes a terrible knock. The search for underlying laws in nature and in the social world (which are, in fact, inextricably linked), is one of the ways in which the world can become known (Haraway, 1991). Galileo's 'book of nature which is written in the language of mathematics' is one book. Many others can be written. A choice of one method implies certain constraints with regard to what it is we wish to know. The philosophical question remains whether the choice of method will prevail (cf. Descartes' *Regulae*, 1966) over the choice of themes in our knowledge acquisition. A rich, multi-coloured knowledge of the world cannot do without a great diversity of methods and methodologies.

TEACHING

Returning to the teaching of statistics, teachers are challenged in three respects. 1) Pupils need to have access to the statistics that are used daily (such as the use of statistical data, tables and graphs in the media and in other non-scientific sources) and to the theory of probability (for example, relevant to games of chance like the lottery). This basic mission fits in with a type of education that aims at mathematical literacy or the so-called numeracy (visible, useable and constructible numeracy) (Jablonka, 2003, p. 75; Kanes, 2002, p. 385). 2) A second aspect of mathematical literacy is the ability to evaluate mathematical and statistical practices which appear in the surrounding culture. Teachers are challenged to teach their pupils so that they can interpret and handle statistics in a correct and critical way. This task is in line with the notion of educating pupils to be critical. 3) Lastly, statistics education will need to give attention to the critical application of statistics as a research method. Hereby, insight into the scientific-philosophical debate is important background information.

This does not imply that pupils have to know the complete history of statistics nor that they have to study the complex connection between mathematics and statistics and its meaning within the philosophy of sciences. Instead of a pure technique-oriented curriculum, there has to be some room for the historical, philosophical and political aspects of the statistics curriculum. This should empower pupils in their use and interpretation of statistics. We have to look at the curriculum at two levels. On the one hand, we have to look at the *content* of the curriculum; on the other hand, we have to be aware of the *way* statistics is taught, the didactics. Both the content of the curriculum and the didactics are indeed tied together. We have to be aware not to teach a solely technique-oriented curriculum without any room for critical reflection. A technique-oriented curriculum hands down statistics as the performance of techniques without any reflection or interaction and it is generally based on a top-down approach. It has, therefore, not portrayed statistics as a reflective subject and there is less room for interaction during the educational process. Moreover, a top-down approach is at the same time an impersonal learning process (Bishop, 1988). The emphasis on the individual process of learning and understanding can give us an insight into the problems and the struggles of the learners. Furthermore, some 'false' or 'mistaken' answers can show a truly logical reasoning behind them (Batanero, 2006, forthcoming).

Both for the implementation of the historical, philosophical and political scientific-philosophical background information about statistics and probability theory, and for the use of a new didactics in which interaction is central, cooperative learning may offer a solution. In this contribution we will concentrate on the didactics "Cooperative Learning in Multicultural Classes" (CLIM). CLIM is a cooperative didactics based on Complex Instructions (CI) as invented by Elisabeth Cohen at Stanford University in order to foster the participation of inner city kids in the educational process (Cohen and Lotan, 1997). The method basically consists of giving a challenging task to a group of pupils which has to be solved by them following a highly structured procedure. Each of the pupils is assigned a specific role. In total there are five roles and each pupil shall at a given point in time take on one role within the execution of the task. In this way, pupils are being made dependent of each other. They will have to draw as much as possible on each other's capacities to fulfil the task. Because of this principle of rotating roles, every pupil is confronted with varying duties among which there is always at least one that he or she is able to perform well. In this way, they learn by doing and simultaneously learn the strong and weak points of themselves and of the others. The task is carried out by the pupils only. The teacher is the initial organiser and mainly functions as a mediator; that means he or she will interfere, especially when asked by the pupils to do so. Equally important is the concept of 'multiple abilities.' As each activity in CI/CLIM focuses on a different ability, the pupil who has acquired this ability already will gain in importance to the group. In combination with the rotating roles, a changing – rather than fixed – status within the class can be created. Status-treatment is therefore a major prerequisite for learning to deal with diversity. Materials developed for cooperative learning are characteristically open-ended; they are task-oriented and they depart from interaction and focus on topics that relate to social and cultural diversity. It would lead us too far to develop this method here with regard to one aspect of statistics education, but it is certainly a gauge which we want to take up in the future.

CONCLUSION

Education in statistics and probability theory is part of the more general mission of stimulating mathematical literacy. It is thereby faced with a threefold task. Pupils need to be given the opportunity to understand the information surrounding them and, moreover, to interpret and evaluate it critically. In a later phase, students (who themselves get to work in research) should be able to question and dare to question the production of knowledge. Teaching statistics will have to be more than just the rigid passing of 'difficult' (mathematical) techniques. Broadening the subject (by integrating history, politics and philosophy) contributes to numeracy in a more general sense. This broader interpretation of statistics education requires a new didactic approach within which cooperative learning can prove a fascinating entry. Not only does statistics education become more attractive and more accessible to 'non-wizards at mathematics' in the process, it also allows for interaction in the learning process, which creates room for pupils' different cultural backgrounds, interests and meanings. In this way mathematical literacy can become a skill for each pupil, which is beneficial to their functioning in society.

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