

## SPECIAL ISSUE “COUNTING, DEMONSTRATING, FORMALIZING”

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### COUNTING, DEMONSTRATING, FORMALIZING

**RIGAS ARVANITIS AND MICHEL GROSSETTI**

Calculation and mathematical formalization is an important aspect of knowledge. For this reason, our journal is devoting a special feature to this theme which is in all probability only the first of a series to come.

For this feature we have chosen: two authors of reference in the sociology of sciences, Bruno Latour and Donald McKenzie; an author on the way to becoming an international reference on the question of demonstration, Claude Rosental; two young researchers who have written some remarkable theses, the first, Jérôme Lamy, on the history of an astronomical observatory and the second, Hélène Guillemot, on climate modelling in France. These diverse articles enable us to give a picture of the multiple facets of the activities of calculation, demonstration and formalization and the way to approach them in the social sciences.

Bruno Latour presents the recent book by Reviel Netz, *The Shaping of Deduction in Greek Mathematics: A Study in Cognitive History* (2003, Cambridge, Cambridge University Press), which he considers as “the most important book of science studies to appear since Shapin and Schaffer’s *Leviathan and the Air-Pump*”, and “offers for the origin of formalism what Shapin and Schaffer have done for the origin of experimental science”. What interests Bruno Latour in Netz’s book is the central place it gives to graphical (diagrams) and written (mathematical language itself) formalizations, the materialization of relationships that mathematicians endeavour to preserve in whatever support they are using.

Donald McKenzie reviews the notion of “finitism” put forward long ago by Hilbert (which can generally be summarized by saying that mathematical entities can only result from finite developments) and taken up again by historians and sociologists of sciences including in particular Barry Barnes, in the sense of an impossibility of identifying general properties that would stand up to the effects of context (which sums up well the quotation from Barnes pointed up in McKenzie’s article (“[N]othing in the rule itself determines its applica-

tion in a given case” (Barnes, 1995, p. 2002)). McKenzie uses the perspective of finitism to shed light on mechanisms of accounting starting from the case of a company quoted on the stock exchange using an integrated management software (*Enterprise Resource Planning*, ERP). Interviews with members of the financial department of this company enabled him to show that in spite of the constraints imposed by ERP, the application of nomenclatures is always contextual. That enables him to argue that the regulation of accounts by an ever more precise formalism is doomed to failure.

Claude Rosental has conducted a considerable amount of research on the question of demonstration, delimiting a space which embraces formal mathematical demonstration as much as the demonstration of technical artefacts similar to the demonstration method concerning household electrical appliances (Rosental, 2003). He aims to show in this article, which refers back to several of his previous research studies, that “the demonstrations cannot be reduced to a description in terms of proof and persuasion, (...) the latter elements can for example play a role of observation points for the demonstrators of transactional support, as an instrument for project management, a capitalization tool or indeed a means of establishing relationships”. He then arrives at a broad definition of the demonstration: “it appears in fact that as a general rule, the term ‘demonstration’ can be usefully employed to refer to a written or audiovisual development, a progression, whose avowed purpose is primarily one of examination and/or of argument, or even instruction, but which can just as well play other roles”.

Jérôme Lamy focuses his attention on the calculation practices of Toulouse-based astronomers, from the aristocratic scholars of the XVIIIth Century to the university academics of the early XXth Century. He brings out the importance of those “invisible technicians” to whom from the outset the astronomers subcontracted a portion of their calculations. In the beginning it involved a small number of associates with varying degrees of versatility. However, in the most recent period of his investigation, the beginning of the XXth Century, it had become a complete department operated exclusively by female assistants (the “ladies’ office”) with a strictly defined division of labour, the women concerned carrying out basic operations, under the supervision of others with the role of “checkers”, and paid according to the degree of difficulty of their tasks.

Hélène Guillemot examines exchanges between the mathematical models for climate and the difficulties raised by their validation by climatologists’ observed data. She centres her examination on modelling practices, studying the work of the major climatology laboratories in France. In the case of climate models, given the importance of the stakes involved in climate change, the economic and social controversies are sometimes conveyed as being as a calling into question of the models themselves. She examines the practices adopted by modellers as an autonomous activity, distinct from that of experimental physicists and climatologists who gather data yielded from observation. Her findings show

that the forms of validation, or more modestly of assessment of the large-scale climate models, become defined through a continual to-ing and fro-ing between observed data and information gleaned from modelling, but at smaller scales than those brought into play by the models.

Some classical questions of the philosophy of science and epistemology are found in these works. The question of the validity of data links back into that of their construction – in the true sense, in other words to the construction of hypotheses, equations and other formulations which can feed the demonstration, model or vision of the skies. Correspondence between the reality and its model rests on observation points – highly tangible for the astronomical or climatological sciences, more dematerialized in the case of mathematical demonstration, in Netz or Rosental – and on an intense exchange of data and accounts relating to the subjects dealt with. There is a continuum between the production of calculations and the observation, an account which links up the specific formulations necessary for the demonstration, and a network which is both social and semiotic in which ideas, models and demonstrations circulate.

Certain philosophers and social sciences researchers, basing their approach on an abstract, ideal conception of scientific activity, sometimes find it difficult to accept this relative flexibility and fluidity of scientific activity and in particular that of scientific “data”. Nevertheless researchers, as H el ene Guillemot neatly reminds us, accept this more easily when they talk for example of “compensations for errors” or “assessment of a model” *to show that it is “good enough to be useful”*. Or again, when they admit that this assessment “[...] requires astuteness, creativity, more than adherence to a method”.

All the articles in this special feature emphasize above all, from the diagrams of Greek mathematicians to laborious operations of the female calculation assistants of Toulouse observatory, by way of McKenzie’s management programs, the robots that supposedly incorporate mathematical results of Rosental, or the reworked and “parametrized” data of climate modellers, that mathematical activity is not a solely a mental, solitary practice; it is also collective work that makes use of material devices and a wide range of supports.

Latour even maintains that it is the concentration of this collective work in mathematical forms which gives it its specificity. The “flat laboratory” of mathematicians is made up of those figures, diagrams and data that have meaning only in the mathematical world. Permanent tension is created around this materiality between the contextual and the universal, between the “here and now” and the “at any time and in any place”.

Therein lies the second “oversight” of a certain philosophy of sciences, which in the end always thinks of a solitary person doing calculations, alone before the problems to solve. Yet if there is one strongly distinct characteristic of calculation, demonstration and modelling activities it is their collective nature. In both the senses we could give to this term: by the manipulation of subject matter

which is always the result of a great number of activities conducted by many different people, but also in the sense of a collective system of referencing. The example of Elkan's theorems which Rosental brings up is particularly illuminating in this respect. There is indeed a collective process of elaboration, with successions of proofs, and series of demonstrations. But it would be stopping in mid path if only this aspect were to be stressed, essential as it may be. These articles show also that these chains of operations – by their ever-increasing complexity, involving at each stage new “specialities”, specific points of expertise, data that are increasingly sophisticated to the point of overturning the very meaning of the word data (as is the case in climatology where the data become almost more malleable than the results from model simulations) – are themselves becoming the focal point of scientific effort. The data, normally taken to be a kind of expression of the observed reality, are the input for, as much as they are the result of, this intense effort of a scientific world and the subject it studies. This reciprocal knowledge held by the actors involved, founded on intense interaction around scientific topics and resources, should be at the centre of any discussion on science and its ability to describe the world.

It must also be pointed out that the subjects of scientific study in the pages of these articles are indeed of the strangest sort: calculations of celestial mechanics, calculations of reduction, geometric figures, mathematical relations expressed by letters, models, simulations and demonstrations. Our authors set out the types of knowledge used, their materiality, their attachment to practices, their constant fluidity. What is relatively evident in experimental fields is more surprising in the more formalized activities: modelling, geometry and finally the demonstration itself, whether it be in the modern (Rosental) or classical (Netz) form.

For our authors, the reality supposedly described for example by the models is carried in the data. The latter are not the result of some “magical” inference from data towards the model – or the inverse, of a “pure” deduction from the model towards the results – but are the product of incessant circulation of data, constrained experiments and verifications performed on sections of models. There is nothing more malleable than the “data”, which only take on their formal role as such once integrated in the unceasing flow of exchanges between distinct mathematical worlds, either in the general space or within the speciality.

The data (in the broadest sense, both resulting from models and demonstrations in the form of results, or as input to tools for calculation, observation and simulation) and the more general concepts used to describe the world are constructed at the same time, locally. In the scientific field of climate, as Hélène Guillemot stresses, “the referent with which the simulations are compared is not ‘the climate’, it is a set of restructured data selected from the hundreds

of thousands provided by the instrument networks on the earth, seas and in space. Only a world fitted with instruments, duly prepared for this, is capable of providing the data that will put the models to the test.”

The extremely short life of the ethnology of mathematical practice has already detected a high degree of variability. This diversity is the most persistent result, the one most invariably repeated by the anthropology of knowledge in a number of fields (see previous issues of our Journal). Diversity of techniques, diversity of forms of calculation, diversity of artefacts. This diversity is what allows the world to be divided into smaller spaces, which can for example be perceived by measurement and observation tools, delimited for experimentation or defined in demonstrations.

Mathematicians, calculation specialists and “demonstrators” perform an enormous effort to keep a world which seems ever determined to escape from them within the narrow limits of their models, graphical representations and data. Claude Rosental devotes a large portion of his analysis to observation of this will to master the “variable docilities and resistances which greet [the demonstrations]”. It is this same proliferation of connections with the “real world” which has made climate modellers particularly cautious about the possibility of truly “demonstrating” climate change.

Going further into the detail we see a complex world unfurling, one made not of the logical and epistemological simplicity that would be the prerogative of mathematics but arrayed with tools, developed, or armed should we say. The Greek mathematicians’ graphic representations and formalism were some of the first elements of such developments. The assistants assigned to help astronomers perform ever more complex calculations were another manifestation of this before the arrival of calculating machines and then, of course, computers. The “flat laboratory” of mathematics thus becomes a distinctly more strongly dimensioned world. The very notion of calculation sees itself transformed because it generates universes that are constructed, virtual, collective and extremely complex that open up possibilities that are always new to research. These universes are moreover international and represent referents for political and social discussions with a scope previously unknown, as the example of the IPCC shows (Intergovernmental Panel on Climate Change).

All the articles furthermore raise the question of our approach to complexity in the social sciences: in the end a core question in these articles. One way is proposed by Claude Rosental, who immediately calls it into question, as he brings our attention to the stage management aspect of the demonstration. The demonstrations Rosental presents are in fact set-up pieces, and for each representation, creation of connections with and within specific communities stem from discussions. They are, Rosental says, the very place for social linking: “For researchers reputed to be loners, whose activity proceeds solely in their

mind, and who for the sociologist constitute *a priori* the extreme figure of the individual, the demonstration activity often represents one of the main sources of social liaison.”

Even stopping at this aspect – and we encourage the reader on the contrary to continue this reflection and read these articles which emphasize many other dimensions besides – these are pioneering articles. They testify to the development of a field founded on the history and sociology of mathematical forms, a field which fully belongs to the anthropology of knowledge that we uphold in this journal.

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**Rigas Arvanitis**, research director at IRD, sociologist, member of the research unit « Savoirs et développement ». He studies scientific communities in the developing world and technological learning in particular in Venezuela, Mexico and China. He co-direct recently a special issue on science in non hegemonic countries in this journal (RAC 2008/3). He now works on European projects on science policy in the Mediterranean region

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ADDRESS:	IRD - Savoir et développement 32, avenue Henri Varagnat 93143 Bondy cedex FRANCE
E-MAIL:	rigas@option-service.fr
WEB:	<a href="http://rigas.ouvaton.org">http://rigas.ouvaton.org</a>

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**Michel Grossetti**, research director at CNRS, sociologist, is member of the Laboratoire Interdisciplinaire Solidarités, Sociétés, Territoires (LISST). The study of scientific institutions is among his research topics. He has published among other books, *Science, industrie, territoire* (1995, Toulouse, Presses Universitaires du Mirail) and directed a collection of essays with Philippe Losego *La territorialisation de l'enseignement supérieur et de la recherche. France, Espagne, Portugal* (2003, Paris, L'Harmattan).

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ADDRESS: LISST-CERS, Université de Toulouse le Mirail  
5, allées Antonio Machado  
31058, Toulouse, cedex 9

E-MAIL: [michel.grossetti@univ-tlse2.fr](mailto:michel.grossetti@univ-tlse2.fr)

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