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Toward an Anthropology of Graphing

An Introduction

> The consensual nature of mathematics is expressed and described mathematically; that is, it is available in the actions of doing intelligible mathematics. To say this does not imply that mathematicians' practices are given a complete and determinate representation by mathematical formulae but that no such representation can be constructed and none is missing.[1]

This is a book about graphs and graphing both 'in captivity', that is, when scientists do graphing tasks posed by a social scientist, and 'in the wild', that is, when scientists use, construct, collect data for, and interpret graphs in their everyday work. I had come to do this research because early on in my work on scientific representations I wanted to have some samples of expertise to be used as reference for the graphing practices that I observed among high school and university students. It turned out, and I can say this much without anticipating the results reported in the first part of this book, that a number of practicing scientists did not exhibit expertise on my tasks in the way that this is often defined in the literature on expertise. The scientists did not exhibit expertise although the tasks were taken from introductory university textbooks in their own field. On the other hand, when the scientists explained graphs that they had produced themselves, they talked a lot about the contextual details of the object they studied, methodology they used, typical problems they encountered, and so on. I had the hunch that expertise in graph interpretation was a function of the familiarity with the 'system' that the graph referred to and with the particular way of constructing graphs in that context. Following this hunch, I subsequently conducted several ethnographic studies of graphing in the workplace; in this book, I report on graph use and graph interpretation by a water technician working on a farm where she monitored the water levels in the creek, by ecologists concerned with understanding the life history of reptiles, and vision biologists investigating the absorption of light in salmonid retina. My analyses show that scientists engage much less in making inference from graphs as articulating what they already understand and establishing coherence with features that they detect in the graphs. In this chapter, I present a general introduction to the field of scientific representation and outline some details pertaining to the study of graphing 'in captivity'. I want to lay the ground that makes it plausible for taking an anthropological approach to graphs and graphing.

1.1. GRAPHING IS PERVASIVE

Graphical representations, which in the sociology of science and in postmodern discourse have come to be known as *inscriptions*, are central to scientific practice. They are tools used for analyzing and understanding many scientific phenomena and are central to the rhetoric of scientific communication.[2] In fact, scientists and engineers become dependent on graphical representations so that, in their absence, they fail to accomplish tasks, interrupt meetings in order to fetch some representation, or at least use gestures to reproduce transient facsimile in the air.[3] It is virtually impossible to find a science textbook or scientific journal without graphs and diagrams. A recent survey of more than 2,500 pages from ecology research journals showed that there are 14 graphical representations per 10 pages.[4] A similar survey of chapters and journal articles from different disciplines reported about 11 representations.[5] We can say that graphing practices, which includes producing, reading, and interpreting graphs, are central to not only to scientific communication but also to the scientific enterprise more broadly.

Graphing is an interesting practice because people of all ages experience difficulties when asked to produce or interpret graphs.[6] Even those who have graduated with a college or university science degree have difficulties interpreting graphs and data more generally,[7] so that some central question pose themselves: 'What are the graph-related practices of science?', 'Are scientists equally competent reading familiar and unfamiliar graphs?', and 'If scientists are much more competent than recent university graduates, what are the experiences that allow the competencies to develop?' These are some of the questions that led me to the research reported here.

In the opening quote, Michael Lynch makes the point that any understanding of intelligible mathematical practice is expressed and described by observable mathematical activity; and no description of mathematical practice can ever be complete. In contrast, many researchers interested in graphing seek mathematical understandings exclusively in individuals' heads rather than in their public activity of doing math. There is no problem with such an approach if it is considered to be part of a more general research agenda towards understanding graphs and graphing. However, there are problems with such an approach if the research concerns itself *only* with mental processes as inferred from behaviors on narrowly specified tasks while omitting to investigate graphing in the natural settings where it occurs. Much of what we do is situated and we take the resources we need directly from the context and use it in task-relevant work.[8] Thus, to read and interpret a graph, a reader does not have to represent it (for example, by visualizing it) in mind in its entirety together with the caption. Rather, attention and short-term memory can be understood as pointer systems that reference objects in the world to pick those aspects that are then picked and represented for explicit reasoning.

Another aspect that is not captured by research on mental processes pertains to those activities (sometimes referred to as 'routines') that we engage in because this is the way we learned them without questioning or understanding the structure. For example, most people in a given society speak its language, but few know the grammar said to underlie the language in any explicit form. We do not need an explicit representation of grammar (the underlying rule-based systems), and know our way around the world.[9] The research concerned with this domain generally does not speak of skills and explicit knowledge, but about the practices that are characteristic of particular socio-cultural groupings, communities, and so on. Human beings can be competent even without having theoretical that is rule-based understandings of their practices.[10] We do have practical understandings, which, however, normally obtain only local coherence rather than global coherence. Pertaining to graphs and graphing, there too may be 'know how' that is not available in any explicit way. This book is about articulating features of graph-relating expertise not normally covered in the literature.

A final motive for engaging in the research reported here and in writing this book is my dissatisfaction with the deficit thinking that pervade the (especially educational) literature as it pertains scientific and mathematical practices. Because existing models are often based on research with 'experts' and 'novices', they are normative in the sense that novices are said to lack what the experts have. However, I have not seen clearly being untangled personal experience—familiarity with the lived world, its representations, and translations between the two—and structures that are said to characterize 'expert' reasoning. It could be that the changes individuals undergo arise from their familiarity with the topic and an associated change in the relation between the signifiers they use and what they want to do with them. Learning is simply associated with changing ways of doing things in a continuously changing world. Most importantly, it could be that sign (representation, inscription) use is irremediably mediated by

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