Engineering Writing/Writing Engineering

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Knowledge is not found ready-made in nature. Instead, knowledge is constructed in the interplay between nature and the symbol systems we use to structure and interpret it. (See Bazerman, *Shaping Written Knowledge,* 291–317, for a discussion of the way nature and the statements we make about it limit one another.) Over the last ten years, this notion of the construction of knowledge has become increasingly accepted by those of us in the humanities and social sciences. We talk, therefore, of language, and particularly written language, as a tool for constructing ideas, of a given field of knowledge being created by the interaction of its practitioners' texts, and of knowledge itself, including scientific knowledge, as rhetorically shaped. (See, for instance, Lefevre; Bruffee; Nelson et al.; and Latour, *Science in Action.*)

We accept the idea that our knowledge is shaped by our language. But this view of language and writing is not necessarily accepted in other parts of our campuses, as those of us who teach engineers, for example, can attest. Engineering defines itself as a field concerned with the production of useful objects. In keeping with this concern, engineers tend not only to see their own knowledge as coming directly from physical reality without textual mediation, but also to devalue the texts engineers themselves produce, seeing them as simple write-ups of information found elsewhere.

Scholars and teachers of technical writing have, to some degree, tended to share this view. Several of our most significant studies of engineers' writing, for instance, examine the way writing is used to transmit engineering knowledge rather than to generate it (Allen; Paradis et al.; Broadhead and Freed). Technical writing textbooks, too, often present writing solely as a means to report on what the engineer already knows. Mathes and Stevenson's influential *Designing Technical Reports,* for instance, enjoins the engineer to shift out of a technical mode and into a report writing mode when getting ready to write (3–8). Writing is viewed as part of an engineer's job but not as part of engineering, which presumably happens in some separate, prior realm (cf. An-

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derson 3–6; Houp and Pearsall 8–9; Lannon 8). Insofar, however, as engineering is knowledge about objects and how to build them rather than the actual building itself, it is necessarily a symbol-bound field. That is, even this field, which seems so tied to physical reality, is necessarily accomplished through language.

While our theory says, then, that engineering, like all knowledge, is filtered through language, studies have not yet shown how engineers' writing would look when contemporary views about the textual shaping of knowledge are applied. This paper is an attempt to fill that gap. The basis for this paper is (1) a file of engineering documents, (2) comments made on those documents by a mechanical engineer who had participated in the engineering activity they described, and (3) the engineer's own activity as he wrote a technical paper he later presented at a professional conference. The engineer, whom I will call John Phillips, had a Ph.D. in Mechanical Engineering. Phillips had about fifteen years of work experience and was a middle-level manager in the Research and Development department of a large manufacturing company. He had the file of documents because he was using them to write a paper to be presented at the national convention of the Society of Automotive Engineers. His paper described his research group's efforts to lower an engine's emissions in order to meet new standards issued by the Environmental Protection Agency. Phillips anticipated that other researchers would find the information useful in working toward lowering their own engines' emissions, although his results would have to be adapted by them to suit their own engines' different configurations. Examination of the texts Phillips used and the one he produced suggests the way engineers write both their knowledge and themselves.

Writing Engineering Knowledge

Textual mediation of knowledge is difficult for engineers to accept because they see themselves as working directly on physical objects. Examination of the documents Phillips was using, however, showed that most of the reports he had were based on written material more or less distant from lab results and that lab results themselves were writing. In the lab, engineers use instruments, which are materializations of previous knowledge, to translate physical objects into written data which can then be manipulated and studied. Some lab instruments, such as a spectrograph or computer, actually write directly on a piece of paper. Others, such as a temperature gauge, translate physical phenomena (such as heat) into a useful written form (such as numbers). As Karin D. Knorr says,

> In the laboratory, the "texts" are provided by constantly accumulated combinations of measurement traces (graphs, figures, printouts, diagrams, tables, etc.). (352)

These "texts" are then interpreted in order to become engineering knowledge. Numerous researchers have established the degree to which data fail to speak for themselves and are instead the subject of interpretation (see, for example, Knorr; Law and Williams; Latour, *Science in Action*). For the most part, this interpretation too is carried out in writing.

This reliance on writing has been shown to be present in the work of scientists. In *Laboratory Life,* their study of laboratory scientists, Bruno Latour and Steve Woolgar noticed the omnipresence of writing. Latour and Woolgar concluded that the objective of lab activity is inscription, the conversion of physical reality into written documents ranging from lists of numbers to published papers. Inscription can be seen as happening in a chain because, although documents are written as though they refer directly to physical reality, they actually refer to and are based on other documents. Documents produced later are valued as they are able to generalize the content of a larger number of earlier documents. For instance, a lab report giving pieces of specific data can be used, along with other such reports, to create a curve showing a trend. The curve can then be used to support a theoretical claim in a paper. Knowledge is thus constructed through texts, not discovered in the original process of lab work.

Moreover, the textual construction of knowledge is social in nature because each document must convince other people of its validity in order to be accepted as knowledge. Only documents that do convince others are used. Documents that for any reason cease to be convincing cease being treated as containing knowledge. Thus, for instance, twentieth-century scientists do not treat the contents of astrology texts as knowledge, although fourteenth-century scientists did. In effect, knowledge may be defined as that which most people in a discourse community are convinced of, and what a discourse community is convinced of is indicated by the texts it has accepted. (See Bazerman, "Scientific Writing," for a survey of research in the social construction of scientific knowledge. See Dobrin for a discussion of the relationship between objectivity and social construction.)

Engineers' Reliance on Writing

The phenomenon of inscribed knowledge, which Latour and Woolgar observed among scientists, is also seen in the engineering documents studied here. To some degree, this sameness is surprising because engineering differs from laboratory science in that it more immediately aims at practical application (cf. Miller, "Ethos"; Miller and Selzer). It is supposed to result in a physical product (in this case a low-polluting engine) whose success or failure in the marketplace is the measure of the engineer's work, as an influential, frequently-cited paper is of the scientist's. For the technologist, writing is a means to the end of producing an object. Knowledge is built for this end, rather than valued for itself. The engine, rather than a document, is "final publication" for the engineer. There is, therefore, a temptation to see engineering writing in the way engineers do, as incidental to the project at hand.

Examination of Phillips' work, however, reveals that, while for him writing is not the final product, it is an essential means by which that product is created because it is the essential means by which engineering knowledge is created. Thus, when Phillips sat down to write his paper, he did not begin by looking at the engine. For one thing, as a subject for a conference paper, the engine both existed too publicly and did not exist at all. It existed too publicly in that it was being produced, and other engine researchers could buy one and look at it directly, so they did not need the paper to know about the engine. (According to Phillips, however, it was unlikely competitors would look at the actual engine. They too would be most likely to consult a document—in this case certification reports filed with EPA—rather than the object.) The engine discussed in the paper did not exist at all in that the actual numbers for fuel economy, pollution, power, etc., reported in the paper came, not from engines actually being produced, but from engines set up in lab test cells. Those engines had long since been torn down and the cells devoted to other purposes. So the paper necessarily drew, not on contemporaneous physical lab results, but on results and analysis already written and interpreted in other documents.

In writing his own paper, Phillips used a file of documents written by other people in his workplace. The bulk of the documents he had were, in order of their production, data sheets, handouts from oral presentations, and what his company called Progress Reports and Technical Reports. Data sheets are computer-produced lists of numbers generated in a test cell. They are produced by placing a probe in the engine to measure a variable (for instance, nitrous-oxide emissions) and then changing a condition (for instance, temperature) in a controlled way. The computer records results at various points and prints them out in a list engineers analyze to determine their success or failure in meeting government-mandated emission standards. Data sheets were unique among the documents Phillips had because they were the only ones produced by looking directly at physical reality. Every document subsequent to them was produced by looking at least partly at other documents. Thus, the computer was the only "writer" here not writing from previous texts.

Though the computer writes directly from observation of an object, its writing is still socially shaped. First, the computer and its attached instruments are materializations of previously agreed-upon ways of structuring the world. The temperature scales used, for instance, are human constructions as is the language through which the computer functions. Thus, while nature certainly acts upon the computer, the reading the computer gets is coded by the society which built the computer. Second, the computer's activities are determined by the research program of Phillips' company and, in this case, of the larger society represented by EPA, which directed that low-pollution engines should be built. Thus even the depersonalized writing of the computer is socially shaped.

Phillips had a few computer-generated data sheets but not many because, as will become apparent, the information in the data sheets had usually been transformed into a more generalized form in another report. Phillips found these later forms more meaningful and more useful. One can distinguish here between a document's authority and its usefulness. Data sheets were the most authoritative evidence in that later documents could not contradict them once they had been accepted as accurate. But data sheets were also the least useful for Phillips in writing his paper because, despite their socially-constructed aspects, they contained the least interpretation, the least meaning. Interpretation and meaning were provided in later, supplemental documents.

The most common later documents were figures from oral presentations. Phillips had eight sets of handouts from presentations given by two people who worked for him. At one point, he called these handouts, not the engine, "the raw material" of his paper. In Phillips' company, most decisions about research are made in meetings at which engineers orally present their progress to management (cf. Paradis et al. 297). Phillips said progress was reported orally rather than in writing because meetings took less time than writing and gave an opportunity for group discussion, that is group interpretation, of the data—social construction of facts. As he said, "People can look at the data and make different comments than other people might. Or they'll say 'gee that's good but that's not so good.'"

The oral nature of these meetings, however, does not mean that they are free of writing. At the beginning of these meetings, speakers pass out handouts. Each page in the handout is a copy of a slide or transparency the engineer will show in his or her presentation. That slides or transparencies are on film rather than paper does not change their written nature. The handouts are simply a more conventional version of that writing, provided so that each participant can have a record of agreed-upon knowledge. Those present at the meeting use their handouts to make notes on, thus modifying the speaker's text to reflect and solidify the agreement reached orally at the meeting. Thus Phillips had made pencilled additions to the various sets of handouts. In one set, for instance, he bracketed two curves on one page and indicated that the difference between them was 20%, as those at the meeting analyzed how much progress they had made. On another page, he supplemented a graph showing what would happen to one pollutant under a given condition with numbers showing what would happen to a second pollutant not originally shown, as those at the meeting discussed how conditions that would help reduce the first pollutant might increase the second.

In addition to reflecting group interpretation, these handouts were more useful to Phillips than data sheets because of their graphic form. Usually the first sheet of the handout gives the title and perhaps an outline of the presentation, and then all the others are graphs of some sort. These graphs are some-