13 WRITING AND KNOWLEDGE MAKING: INSIGHTS FROM AN HISTORICAL PERSPECTIVE

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In recent years, academics, business people, and the media have come to refer to our economy as information based and knowledge driven; we laborers in this enterprise identify ourselves as knowledge workers. One only has to look at the greater number and diversity of technologies by which we communicate and the emphasis on research and development by governments, industries, and universities to see that the accumulation, dissemination, and use of knowledge is a major activity of workers today. In today's economies, particularly in developed countries, texts contribute in measurable ways to the exchange and value of goods and services, while globalization, specialization, and new technologies have increased the need for workers to have mastery of higher order literate skills, such as expertise in science and engineering.

Anxious about how the process of formal education might help prepare students for this new world, researchers, educators, employers, and workers are paying closer attention to the role of workplace writing practices with an eye toward understanding the relationship of writing with productivity and competitive advantage. Implicit in these concerns is the notion that while higher education has successfully prepared graduates for a heavily industrialized society, it must adapt if it is to be useful in the dynamic (and even revolutionary) environment of contemporary globalization. In this chapter, through a synthesis of historical, sociological, and philosophical material, we endeavour to redefine writing and how it contributes to knowledge production in the context of the knowledge society and writing pedagogy in higher education.

While educators perceive a need to respond to the demands of "the knowledge society," scholarship in writing practices in the disciplines of sociology, history, and rhetoric has recognized that writing practices and products are

intimately linked with what information consumers consider knowledge. Despite this recognition, we have yet to explore fully the ways that this research might inform writing pedagogy. The historical perspective that we use in this chapter reveals that writing is an active participant in the creation of knowledge. It is not enough to recognize simply that written texts contain things we call "knowledge." While this may be true, taken as an end in itself, it leads to the illogical conclusion that since we now have more texts, we "know" more than past peoples. Of course, however useful our knowledge may seem today, it would not help a contemporary time traveler understand or participate in cultural endeavors in ancient Sumeria, for example. Knowledge is not merely a currency accumulated and traded in texts and other media. Instead, it is created by texts. For example, patents create knowledge by defining the ways that ideas can affect the world because of their form and their legitimacy as legal documents.

In North American universities the common understanding of learning to write as instantiated in classroom pedagogies has changed a great deal in the past three hundred years, but has yet to account for the complex role texts play in the construction of knowledge. In the early days of American universities, practice in composing was supported by the study of rhetoric during all four years of undergraduate instruction. Harvard, for example, began its composition courses in 1642, six years after its founding in 1636. The rhetorical emphasis remained until the mid-nineteenth century, when classical rhetoric was supplanted by the study and recitation of treatises. Then, in the early twentieth century many universities employed works of literature as models of style, and these texts ostensibly replaced instruction in rhetoric. Thus, the rhetorical orientation of writing instruction was altered to maintain a new, subjective and class-based attitude toward English studies and writing in particular (Crowley, 1998). In other words, the answer to the question "what is the purpose of writing instruction?" was being answered with a sort of trickle-down theory of composition that emphasized literature and the development of taste. With the notable exception of a new emphasis on communication skills, writing pedagogy underwent very little theoretical development between 1900 and 1970; in the 1950s and 1960s, introductory composition was still being taught according to this "current traditional" pedagogy based on the 19th century model. However, during the 1970s, writing teachers began embracing process pedagogy, cognitive approaches to writing instruction, and writing across the curriculum. These new emphases have remained strong in writing education, fuelled by research and theory related to writing in the disciplines and professions (Bazerman, 1984; Goodman, 1976; Latour, 1987).

In spite of this increased attention, many administrators and faculty members continue to see writing as a general skill effective in any context, and continue to associate writing primarily with literary forms; a high school graduate is considered to possess all of the right machinery, so to speak, to produce texts in a variety of environments. In college, the student then obtains "knowledge." This knowledge ideally can then be channelled into the writing of all kinds of effective texts. However, this process presupposes a system of knowledge representation that is too narrow and simplistic, for it fails to recognize that for students to pass from merely consuming knowledge to producing knowledge, an effective pedagogical system must account for genres that extend beyond academic and literary forms, as well as the situated and social nature of knowledge-making practices.

In fact, the representation of knowledge, whether in a text or any other medium that uses a visual display, arises from the social engagement of actors who must display novel information in forms that are well recognized and meet the expectations of their peers. Because of the need to meet audience expectations, representations of knowledge must employ and adapt existing conventional representations for new tasks. These tasks become even more slippery when one realizes that representational systems do not unambiguously refer to entities in the world, whether they are concrete or conceptual. Furthermore, in many knowledge-making ventures, knowledge representations are achieved through the interaction of multiple genres or genre systems, which "instantiate the participation of all the parties involved within a knowledge making activity system" (Bazerman, 1994). When these four features of knowledge representation and production are taken into account, it becomes apparent that the traditional model of writing education is insufficient to prepare students to write effectively in any field. However, before we can address the necessity of this consequence in depth, we must first consider why the representation of knowledge in texts is the product of social encounters, constrained by convention, necessarily ambiguous, and involves multiple interrelated genres.

SOCIAL ENCOUNTERS

Researchers working in social studies of science in the last 20 years have amply demonstrated that statements in science can constitute facts about nature only to the extent that their authors are able to enlist the support of their scientific peers (Bud & Cozzens, 1992; Doel, 1996; Latour, 1987; Rossiter, 1982, 1995; Shapin, 1994; Traweek, 1988). In order to have their novel observations and problem solutions accepted as scientific facts, Latour points out that sci-

entists must persuade others to take up their ideas and incorporate them into their own articles, books, and other texts. In other words, members of the scientific community determine facts as a result of their assent and acceptance of statements made in reports of research. In Latour's view, fact determination is social not only because it depends on persuasion and assent but also because scientific actors obtain persuasive power through institutions to which they gain access based on social criteria. Only those who have a laboratory may speak authoritatively about nature, and laboratories are communities that, like towns and corporate boards, act based on selfish interests and communally determined standards of right action.

In his *Science in Action,* Latour (1987) demonstrates the collective nature of science by revealing how scientists use laboratories to order information about the world and, thus, control it. Latour (1987) argues that the success of cartography came from its ability to separate information about a place from the local experience of it. During the age of maritime discovery, ship captains regularly recorded and brought back to Europe latitude and longitude for features of interest like land and shoals. One person's report when compared with another's might have only resulted in an incommensurable collection of shapes, but these pilots used the same diverse and expensive array of instruments like sextants, quadrants, and log books so that their data could be recorded in a way that would make it both mobile and combinable with data collected by other captains. These instruments themselves required the concerted effort of tool makers, pilots, and engineers in order to come into being. We might even extend this recursive study of the means and manpower behind cartographic information by pointing out that the ships used in these adventures were also technological marvels and, indeed, instruments that required the concerted effort of pilots, master carpenters, craftsmen, and engineers. The mobile and combinable data collected with these instruments was then returned to the center, usually the national capital, where it could be manipulated and made meaningful by other groups of investigators cooperating in order to create atlases and maps that record what then constituted "knowledge" about the foreign land (Latour, 1987, pp. 223-224).

Latour further emphasizes how these social networks ultimately create knowledge that then may be used by the central authority (whether a state or another institution) to control and dominate nature and human societies and institutions. His is a story of how scientific knowledge itself is power that may be adapted for political, military, and social ends (Rouse, 1987). For our purposes, it is important to recognize that Latour demonstrates that knowledge is not a subject or topic that is contained in a written form. Instead, knowledge is a human creation that requires the combined efforts of

people doing different things. One ship captain's idiosyncratic report of the coastline constitutes experience rather than knowledge. To obtain knowledge, there must be people who write instructions about how to collect specimens, people who are able to navigate in the open ocean, people who prepare star charts, people who record experiences on the expedition, and people who write scientific articles that report what has been learned. Knowledge is a social accomplishment and does not come merely as a result of discovery or empirical observation.

CONSTRAINTS RESULTING FROM CONVENTIONS

People who create knowledge confront a thorny problem since they must represent, in texts, novel information using well-recognized conventions that will be familiar enough to their audiences to allow communication to take place at all. In his study of spectroscopic articles appearing in *Review of Modern Physics* over a period of 100 years, Bazerman (1984) examines how scientists used the journal article to convey information obtained from spectroscopic investigations. In seeking to persuade readers that results were correct and meaningful, authors had to meet audience expectations "of what appropriate writing in the field is" (Bazerman, 1984, p. 165). Since such expectations will always include the proper form for the presentation of argument, they open up possibilities that the writer might not have considered and also impose constraints on what the writer may say (p. 165). In this way, "writing conventions help define the very thing called 'knowledge'" (p. 166).

While writing conventions partly determine the product of scientific investigation, that is, knowledge, Bazerman's (1984) study also reveals that discourse partly determines epistemology, how we know what we know. For example, he notes that, when writers began to use modeling in the 1930s, physicists' beliefs in what might be known shifted. Unlike a report of an observation, a model makes more limited claims about nature. Rather than asserting the existence of a confirmable fact, a model is authoritative to the extent that it accounts for data better than competing models . Thus, by the 1930s, scientific knowledge no longer could consist of true statements about some entity called "nature." Instead, it constituted a theoretical construct situated with respect to approximations based on phenomena observed in the laboratory. In the early spectroscopic articles, it would have been impossible for the writers to represent their research through a model, a discourse convention that was unavailable when writers were expected to make statements that could be judged true or false according to observations. As Bazerman's study reveals, writing conventions may both demonstrate what

counts as a valid statement about nature at a given historical moment as well as shape what a scientist may say about the world.

The historian of science, Hentschel (2002), recently completed a comprehensive study of the visual techniques used to represent spectra of the sun and laboratory samples of elements and molecules, and his work similarly establishes that representations have a life of their own that exists apart from the phenomena under study. Klaus's investigation is particularly enlightening in this regard since the particular representation that he studied is one that many might assume would not allow for artificial manipulation by the scientist-author. One might easily assume that a visual representation of a spectrum is simply the fingerprint of an electromagnetic wavelength recorded on some permanent medium. Hentschel's study shows, however, that different "visual subcultures" employed different kinds of representations that both depended on the visual tradition of the group as well as the purpose for which spectra were studied (p. 60). For example, Isaac Newton's method of representing the spectrum of the sun as a series of circles of different colors persisted despite significant changes in the theoretical understanding that formed the basis of that image (Hentschel, 2002). Johann Jakob Balmer is famous for being the first to represent the relationship between some of the spectral lines of the hydrogen atom using a simple mathematical formula. Hentschel shows that Balmer's ability to see the pattern that gave rise to the mathematical relation of wavelengths resulted from his training as a geometrician who taught perspectival drawing. Thus, Balmer's ability to predict mathematically the location of lines in the hydrogen spectrum arose not out of a fundamental understanding of the structure and behavior of the atom he studied but as a result of the conventions with which he was familiar for representing three-dimensional space.

In the example from Bazerman's (1984) study, we see writing conventions operating to limit what may be known about the world. In the example from Hentschel's (2002) book, we see the novel use of conventions of representation expanding what could be known about the natural phenomena under study. Historical studies by many other researchers have confirmed the importance of conventions, including the genres in which knowledge is represented, as constitutive of what might be known (Edney, 1993a, 1993b; Gilbert, 1976; Gooding, 1986; James, 1985; Kaiser, 2000; Latour & Woolgar, 1979; Simons, 1990). The use of genres and conventions allows for mutual understanding of what might be known and can be highly consequential for the development of knowledge in a particular field (Fleck, 1981). This perspective is highly congruent with work in rhetorical genre studies which shows that genres constrain and enable actions that are available to us, that is, "what motives ... and ends we are able to have" (Miller, 1984, p. 165).

THE AMBIGUITY OF SYSTEMS OF REPRESENTATION

We can recognize that the act of recording information in writing is a creative endeavor when we observe the relationship that systems of representation (like textual statements) bear to their referents. As we point out, as a matter of social practice and as a result of the constraints imposed by existing writing conventions, writers who seek to record or communicate information do not translate the objective experience of reality into symbolic statements. What's more, they cannot. When we represent an idea or tangible entity, our representations—whether textual, visual, or auditory—do not allow us to free the representation from its time, place, and means of production (Goodman, 1976). In order to function as a symbol scheme for faithfully recording what is out there, the symbol scheme would have to operate as a mobile copy of what it represents. This is precisely the model of knowledge that much writing pedagogy presupposes, although most probably unknowingly, since it envisions a representation system that has an existence independent of its knowledge content.

As Nelson Goodman (1976) demonstrates, our representations of knowledge are almost always incomprehensible without an understanding of the time, place, and means of production. Similarity is insufficient to make a symbol function as a representation. As Goodman notes, "A Constable painting of Marlborough Castle is more like any other picture than it is like the Castle, yet it represents the Castle and not another picture—not even its closest copy" (p. 5). While most will agree that painting as a means of representing rests on what we might vaguely describe as "style," we are less willing to recognize that the very nature of representation that prevents a painting from being an unambiguous representation also prevents other forms of representation from speaking unambiguously. Representation is an achievement. With the exception of musical notation, the symbol schemes available for the representation of knowledge do not allow for unambiguous speech.

For a system to be unambiguous, there can be no symbols that intersect semantically (Goodman, 1976). For example, the existence in ordinary English discourse of the symbols "woman" and "doctor" do not permit unambiguous identification of the referent. In addition, the vast majority of symbol systems available to us for representing knowledge do not allow us to determine that a given character is syntactically equivalent to another (Goodman, 1976). In other words, if we exchange one character for another in a statement, sometimes we cannot tell if we have substituted a replica or a new character. We can understand the power and contingency of symbolic substitution if we look at the analogous symbol system of mathematics. In representing conceptual and concrete entities, most generally assume that mathematics, unlike textual representation, is free of

ambiguity, but even mathematical knowledge is historically contingent and ambiguous. For example, in mathematics we may represent numbers on a number line in a sequence from smallest to largest. Any high school student can testify to the ease of using the number line to state inequalities like $1 < 5$. Similarly, when we extend the number line in both directions, we discover that negative numbers are less than positive numbers: $-1 < 5$. The novice can also tell us that when we take a big number and divide it by a small number, we can predict that the result will always be a big number

$$\frac{5}{1} = 5.$$

However, if we take the character "$- 1$" from our inequality and move it to the denominator of our fraction, we observe an anomaly.

$$\frac{5}{-1} = -5.$$

When we divide a big number by a very small number, sometimes we get a very small number. This statement shows us that our character, "-1," may not be a replica of the inscription, "-1." So, even in mathematics, we observe that sometimes an inscription may represent one character and sometimes another.

A little digging reveals that this anomaly results from the historical development of mathematics through texts. Negative numbers entered the field as they became useful to people doing arithmetic in ledger books for commercial transactions (Martinez, 2006). Although useful, they created many difficulties for eighteenth century mathematicians in particular. Previously, numbers had been intuitively and practically associated with quantities and were, therefore, understood to be representative. This association broke down once mathematicians considered using negative numbers for other purposes. After all, what could these expressions mean: $\sqrt{-1}$, -2×-2, or $\log(-1)$? Newton and Leibniz were troubled; Descartes ignored three quarters of the Cartesian plane. What mathematical expressions might mean is contingent because it is the result of an historical process that depended on things external to the expressions themselves, including texts, accounting practices, and contemporary problems in mathematics (Martinez, 2006).

We can see from this historical episode that mathematical use of written symbols depended on social encounters and that the adaptation of the accountants' conventions for the use of negative expressions expanded and complicated mathematical knowledge. It is also important to recognize that the innovative use of symbols to create new knowledge in mathematics actually results (in part)

from its inherent ambiguity. Writers would find it terribly difficult to be original if they had to use a symbol set in which the members had unique, real-world referents. It would be harder to suggest new ways of seeing. We do not argue that innovation is impossible using undifferentiated symbols. Instead, we point out that the kinds of innovations that emerge in text intensive communities (like science) appear to thrive on the imperfection of the reference system.

SYSTEMS OF GENRE AND FRENCH EXPLOSIVES DEVELOPMENT IN THE 18TH CENTURY

Finally, we can see how writings contribute to stabilizing facts about the world from the episode referenced in Bazerman and Rogers (2008) concerning the work of French chemists who developed explosives for the government beginning in 1793. This example is extremely illuminating because during this early collaboration of government, industry, and university scientists, (Gillispie, 1992), multiple genres of writing produced by scientists, researchers, government committees, bureaucratic offices, and military officials figured prominently in virtually every aspect of this knowledge-dependent venture. This mobilization of national resources brought academic, scientific, bureaucratic, and other forms of writing to bear on government policy and through texts made scientists accountable to government authorities. Initial scientific papers and communications with the government about the military potential of explosives helped initiate the project, and many scientific papers and patents also resulted in the creation of mobile information about the world. Documents were also produced by researchers that introduced the codification of new scientific procedures, outlined methods, and provided directions, instructions, models, and procedures for activities such as firing, loading, and using bombs and shells. An example of such documents is the specifications for the fuse assembly of incendiary shells. These texts contributed to unique forms of social organization, to the system of knowledge, and to the further mobilization of people, resources, and technology.

Texts recording the results of tests—such as the systematic tests of particular compositions of incendiary howitzer shells, reports, diagrams, and descriptions of accomplishments all flowed from the researchers to the bureaucracy. Table data from the performing of these tests created a different kind of knowledge, wherein scientists could observe that a regularity was occurring; these effects were later controlled, and without such control the same kind of knowledge could not be made. Also, knowledge from experiments dealing with non-military applications of chemical processes, such as the operations and actions of various fabrics and hundreds of coloring agents used in dyeing, were published,

creating new possibilities of action; these activities played a role in the continued development of the science of chemistry and chemical technology.

In France, the Academy of Science long held sway over what counted as knowledge about the natural world. Thus, bureaucratic texts of many genres played a role in organizing the resources, the scientific side of the research process, and the public dissemination of knowledge through broader publishing activities, including peer reviewed scientific reports. The bureaucracy became a nexus for the manipulation and control of scientific facts, as government and bureaucratic documentary systems intersected with the work of the researchers and scientists by authorizing, funding, and providing accountability for the project. Government documents authorized the initial allocation of resources for facilities and materials, granted permission for scientists to go forward, and transformed the gunpowder administration from what was originally a privately funded operation into an agency of the Ministry of Finance. Routine administrative writing, such as the recording of minutes of meetings, also played a role.

However, while knowledge-making activities can be characterized as bringing more access to knowledge—through the publishing of scientific articles, for example—in this collaboration with government much of the crucial information was kept secret. Thus, while written texts allowed for the emergence of new categories of knowledge, they also excluded participants; that is, this knowledge only existed within the social systems that understood and had access to these writing conventions.

From the military arose a further series of documents which included detailed accounts of the transfer of weapons, plans for the building of arsenals, and strategic and tactical plans for employing weapons, including novel methods of naval combat to defeat the English Navy. In this way, systems of organizing data about the world were exported to systems for organizing people and things in the world.

Personal correspondence, notes, and letters within the government, between ministers and ministries, and with scientists were crucial in the development, administration, and monitoring of the project: secret letters were also written which directed resources and plans for the development of incendiary cannonballs, and which described their composition; specific orders and responses were also included in letters confirming dates and details of delivery methods. Memoirs and autobiographies, which required government approval, were also published.

Bureaucratic texts authorized, centralized, and coordinated the massive undertaking, assisted in the management of materials and people, controlled the secrecy of the work, and facilitated communication among scientists, researchers, military personnel, government ministers, committees, and field personnel.

Together these participants, through the publishing of research findings and other texts across and within a variety of social networks contributed to the foundations of scientific disciplines and future research activities.

IMPLICATIONS FOR PEDAGOGY

The consideration of the link between texts and knowledge from an historical perspective suggests a new understanding of the functions of texts. In this section of our chapter, we propose three foundational understandings of texts and then explore what they may entail for writing pedagogy. In doing so, we recognize that our conclusions are not entirely novel. Other researchers have noted that interrelated texts act within the world as systems of power and control, and others have suggested that we abandon the idea that generic "good writing" practices can be taught. However, we suggest that the synthesis of historical, sociological, and philosophical material that we include here reinforces those conclusions and offers a framework for continuing our research of writing and its relationship to knowledge.

First, we see that texts actively create and manipulate knowledge by making it nth-dimensional. In other words, the character of textual dimensions like indexicality and reference make possible the creation of systems of knowledge. For example, the precise recording and reporting of experimental results, that is, the creation of portable knowledge, led to recommendations by the French Academy of Science to further advance the project of explosives development. Second, writing is a technology that exists as part of a system by which knowledge is deployed in the world. Text and technology do not lie at opposite ends of a continuum of cultural endeavors that might be aligned with the often opposed categories, science (technology) and the arts (texts). Instead, texts are intimately linked with other knowledge-making technologies. Finally, texts naturalize culture, which then makes it manipulable through technologies including other texts. Thus, texts change our perception of the world.

When we consider these conclusions, we recognize that texts do not contain intangible entities called "knowledge." We can find no latitude and longitude in nature; there is no entity, "-1" that can consistently be instantiated in diverse documents and statements (even within the same knowledge field). Knowledge, as in the case of the development of explosives in France, is created by multiple genres (e.g., texts, diagrams, graphs, reports, personal correspondence). Constructing and communicating knowledge about any subject, whether it is art or science, requires the knowledge worker to read, transform, and manipulate symbols.

While our examination of these few historical examples cannot provide definitive recommendations for pedagogy, it does allow us to articulate some expectations that could be explored in future research. The creation of texts makes demands on writers for which a general approach to writing instruction cannot prepare students. This model presupposes that writing is a container for knowledge rather than a tool for knowledge generation. Instead, we expect that students will master writing abilities better if they learn in social encounters in which they develop and reformulate texts with others who are pursuing similar goals. We expect that there is a place in writing instruction for the use of schemas and rubrics if they are discipline-specific, but we anticipate that the use of rubrics will only be beneficial to the extent that students are required to adapt them to confront novel situations. The strict adherence to rubrics could reinforce the notion that texts are containers for knowledge. We also expect that successful writing instruction will occur when text generation and reformulation exist as part of the student's knowledge-making development. In other words, good writing cannot be taught as something separate from subject matter. This does not mean that there is no place for introductory writing instruction. Rather, it suggests that introductory courses that expose students to writing within specific knowledge domains, including case methods of teaching and assigning genres that invite students to experiment with professional roles they will face in the future (perhaps in the instructor's area of expertise) will be most successful. Further, students should be exposed to an expansive range of inter-related professional genres of writing rather than merely isolated instances of academic and literary forms. Finally, we suggest that theoretical knowledge about writing can be incorporated into writing instruction in meaningful ways. Understanding how texts are produced and function can help expose students to writing's many possibilities. Without knowledge of the ways that writing can be used to shape the world and our understanding of it, we anticipate that students will see writing as an obstacle that stands between them and their goals rather than a powerful instrument for participating in the world.

IMPLICATIONS FOR RESEARCH

This synthesis of literature and case study concerning the contexts, conventions, and representative systems of writing practices strongly suggests that writing pedagogy can benefit from being informed by knowledge of how writing has developed in text-intensive communities. At the same time, we hope that this study will encourage other researchers to use historical methods to expand our understanding of writing as a tool for the creation and dissemination of knowl-

edge. Latour's and others' studies of writing as a laboratory practice have been extremely important in establishing the importance of social aspects of writing practices in knowledge driven societies (Bazerman, 1999; Latour & Woolgar, 1979; Pickering, 1984). Bazerman, Hentschel, Miller, and others have revealed the extent to which the use of conventions and writing genres have constructively shaped knowledge, especially in communities of experts. Historians and philosophers have shown us how our symbol systems serve important epistemological roles as well as challenge writers who seek to communicate novel information (Gooding, 1986; Goodman, 1976; Hacking, 1983). Finally, historians with many different areas of expertise have noted how writing practices reflect and influence our conception of information and systems of knowledge. For example, Long (2001) shows that the emergence of texts on the mechanical arts transformed these activities into discursive and learned subjects: "When authors transformed craft know-how into forms of discursive knowledge, they prepared it for integration into philosophical methodologies pertaining to investigation of the natural world" (p. 249). Her study, as well as others, suggests that much additional scholarship remains to be done that will reveal how intimately writing practices are associated with other cultural endeavors. While historians have performed a good deal of research in this area, "only 2.1% of writing research related articles published between 1994 and 2004 were historical in nature" (Juzwik et al., 2006, p. 467); even fewer were conducted with the aim of reaching a greater understanding of writing as a tool of knowledge making.

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