ENGINEERING LITERACY: THE PRACTICE OF DISCIPLINE

BY

REBECCA S. BILBRO

DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in English with a concentration in Writing Studies in the Graduate College of the University of Illinois at Urbana-Champaign, 2011

Urbana, Illinois

Doctoral Committee:

Professor Paul Prior, Chair
Professor Bob Markley
Professor Dale Bauer
Assistant Professor Spencer Schaffner
Abstract

This study is a methodological and theoretical re-mapping of disciplinarity, which seeks to retrace and excavate more nuanced links between enculturation and communication. The work engages original participant research (interviews, classroom observations, and textual artifacts) on communicative practices of students, faculty, alumni, administrators, and staff from the College of Engineering at the University of Illinois. In each chapter, my mappings extend through and beyond typical treatments of disciplinarity, retrieving data trajectories rendered invisible or irrelevant by current conceptual models and proposing analytical shifts to new, more inclusive models. Whereas some current models rely on sharp distinctions between the real world and the academic world, I have tried to accentuate habitual writing practices that transcend such artificial boundaries. Furthermore, while raced, classed, gendered, and queered bodies are routinely absent from disciplinary models, I argue that participants’ idiosyncracies and personal histories index key information about disciplinary values and practices. Mine is a project of recovery, revival, and recombination as much as of remapping, and my dissertation employs methodologies from across the field of writing studies, including historiography, ethnography, sociocultural theory, and rhetorical analysis. Because my research questions are critically informed by many other characterizations of the disciplines, my project also responds to issues in engineering education, feminist theory, cultural studies, critical race theory, and literary studies. By synthesizing lines of inquiry from these canons and expanding knowledge about disciplinary enculturation, I hope to contribute to both of the “Two Cultures,” as well as to the many scholarly places between and within.
To my family of engineers.
Acknowledgements

This dissertation would not have been possible without the “engineering” of many individuals. Deepest thanks to my adviser, Paul Prior, who not only read many drafts of this and other texts, but is also solely responsible for converting me from an emphatically quantitative thinker to an enthusiastic qualitative researcher. Thanks also to my committee members, Bob Markley, Dale Bauer, and Spencer Schaffner—all of them disciplinary exceptions—for supporting me and inspiring me to bravely cross boundaries in my scholarship. Much gratitude also goes to the Center for Writing Studies for facilitating a scholarly community that cannot possibly exist elsewhere, and to the Department of English and Graduate College of the University of Illinois at Urbana-Champaign for their financial support along the way. Finally, thanks to my parents, both of whom are engineers, for periodically reading bits of my writing and assuring me that I was not wildly misrepresenting their discipline, and to my husband, Jeff, for engineering the context that enabled me to complete this work.
Table of Contents

Prologue: The Children of Martha ................................................................. 1

Chapter One: A Fit of Rigor ......................................................................... 6
  Theoretical Foundations and Disciplinary Pasts ........................................ 8
  Methodology ............................................................................................. 23
  Overview of Remaining Chapters .......................................................... 26

Chapter Two: Exceptionally Disciplined ..................................................... 29
  What Does it Mean to Be an Engineer? ...................................................... 32
  Leslie and Michael ................................................................................... 34
  An Expert Novice ...................................................................................... 39
  Essential Information? .............................................................................. 42
  A Professional Student ............................................................................. 46
  Genre Hacking ........................................................................................... 49
  Exceptionally Disciplined ......................................................................... 58

Chapter Three: Enculturation Games .......................................................... 61
  Enculturation as Game-Play ...................................................................... 62
  Playing by with the Rules ......................................................................... 65
  Disciplinary Permeability ......................................................................... 74
  Parallel Play ............................................................................................... 97

Chapter Four: Writing Across the Curriculum, and the Sea ....................... 98
  Mangled Subjectivities ............................................................................. 100
  Le Tronc Commun (The Core Curriculum) .............................................. 104
  Textual Artifacts ...................................................................................... 110
  Political Engineering ............................................................................... 114
  In and Out of School ............................................................................... 117
  Indigenous Mangles ................................................................................ 120

Chapter Five: Home Discipline ................................................................. 128
  Emily ......................................................................................................... 132
  Civil(?) Engineering ................................................................................ 136
  Father vs. Daughter .................................................................................. 142
  Dirt ............................................................................................................ 146
  oSTEM ..................................................................................................... 150
  The Link ................................................................................................... 155

Conclusion: Composing Engineers .............................................................. 161
  Theoretical Contributions ....................................................................... 161
  A Critical, Feminist, Playful Project ......................................................... 166
  Implications for Pedagogy and Practice .................................................. 170

References ................................................................................................. 173

Appendix A: Sample Recruiting Letter to Instructor .................................... 188

Appendix B: Sample Recruiting Letter to Student ....................................... 189
In his turn-of-the-century poem, Kipling alludes to a biblical story from Luke 10:38-42 to illustrate the disciplinary boundaries between those who are destined to be served and those who are fated to serve them. The original story is about two sisters of Lazarus, Mary and Martha, who are anticipating a visit from Jesus. While Martha rushes around, anxiously cleaning and organizing, Mary relaxes. When Jesus finally arrives, Martha tattles on her lazy sister and finds his response to be surprisingly unsympathetic. In Kipling’s poem, we meet the Sons of Mary and of Martha, who have inherited the responsibilities of their mothers.

Just as Kipling’s poem does for the Sons of Martha, so does Susan Miller’s *Textual Carnivals: The Politics of Composition* (1991) conjure up the subjugation of both a field and its members. Miller’s trope of the “sad women in the basement” famously addresses those scholars tasked with the teaching of freshman composition. However, like Kipling’s Sons of Martha, Miller’s sad basement women (perhaps the Daughters of Martha?) are in service not only to the students in their classrooms, but to all the Sons of Mary. Both Kipling and Miller juxtapose the
cursed descendants of Martha (or sad basement dwellers) with their cousins, who live a charmed existence. Kipling writes that the Sons of Mary

    smile and are blessed - they know the Angels are on their side./They know in them is the Grace confessed, and for them are the Mercies multiplied./They sit at the Feet - they hear the Word - they see how truly the Promise runs./They have cast their burden upon the Lord, and - the Lord He lays it on Martha's Sons!

(Kipling, 1907; 33-36.)

In Miller’s case, the blessed cousins are scholars from more revered disciplines (including, obliquely, the social architecture of the university as a whole), and more immediately, literary studies:

    “Composition” and “literature” stand in…for communities who are imagined to be operating in the same institutional settings, but not in the same ways or at the same levels of power…Both look at and act on each other across a boundary that most on either side see dividing “high” from “low.” But neither group has fully explored their original and continuing mutual dependency, the ways that the position of one is actually required by the socially constructed status and larger cultural implications of the other. (p. 2)

This dissertation considers a disciplinary setting twenty years after Miller’s book and more than one hundred years after Kipling’s poem. The primary research site, the University of Illinois at Urbana-Champaign (hereafter UIUC), comprises a very different institutional space from the ones described by Miller and Kipling. Nonetheless, many of the images they introduce continue to ring true in the context of UIUC. While composition studies and literary studies are
today much less at odds than in the chronotopic context of Miller’s *Textual Carnivals*, humanists often see their cousins in science and engineering as Mary’s spawn: blessed by the funding angels at the National Science Foundation, seated at the feet of booming industries, watching how the promise of capitalism runs. But just as Kiplings’ poem casts the Sons of Martha as somehow deserving of their torment (in an “original sin” sense), and Miller’s *Textual Carnivals* ultimately argues that compositionists support and preserve their marginalization, we might ask whether humanists are equally invested in their institutional position as their cousins blessed with technical savvy.

Here at UIUC, engineering is held up as a model of innovation and knowledge production. Both our undergraduate and graduate engineering programs are in the top five in the country according to the *US News and World Report* rankings. UIUC graduates with a BS in engineering will start out making 50% more than those with a BA in English. The federal government gives UIUC’s College of Engineering more than a hundred and fifty million dollars every year to do research, on top of state appropriations of about $75 million annually. More than fifteen percent of all incoming freshman—on average, four of twenty-two students in every freshman composition class—are planning to be engineers. Regardless of discipline, all teachers, scholars, administrators, and tax-payers associated with UIUC are very literally invested in these engineers-in-training, playing Martha to their Mary.

Moreover, despite the hegemonic power structures that seem to keep the humanities in the basement, humanist investments in science and technology (such as the Culture Wars of the 1990s) are often much more than circumstantial. While it may seem to be a Sisyphean task, waiting upon Mary's Sons without “end, reprieve, or rest” can also result in a significant degree of control. Classrooms, for instance, afford non-technical teachers certain cultural, political, and
social privileges over their technical counterparts. Even if a freshman composition instructor knows very little about what his or her engineering students do on a day-to-day basis, or about the signs and semiotic practices of engineering, he or she is likely to be actively informing the enculturation of engineers. And if our hypothetical composition instructor were to look over a cross-section of engineering texts, he or she might be surprised to find that the seemingly foreign canon includes some artifacts local to the humanities. Even more curiously, if our imaginary writing teacher felt any kinship with the overworked and undercompensated Daughters of Martha, he or she would be surprised to discover that for Kipling, the children of Martha are in fact the *engineers*.

Indeed, for Kipling, it is the non-engineers—we who are “pleasantly sleeping and unaware”—who are the Sons of Mary. Kipling’s poem, like C.P. Snow’s (1959) Rede Lecture, delivered at Cambridge fifty years later, comes out of a desperate attempt to draw attention to the hard work of the engineers of our society. The engineering of “The Sons of Martha” is just as literal as it is metaphoric:

> It is their care in all the ages to take the buffet and cushion the shock./It is their care that the gear engages; it is their care that the switches lock./It is their care that the wheels run truly; it is their care to embark and entrain./Tally, transport, and deliver duly the Sons of Mary by land and main. (Kipling, 1907; 5-8.)

By invoking the mechanics of civilization—the gears engaging, switches locking, wheels turning, shocks absorbing, bridges mounting, gates hoisting—Kipling beseeches humanists to have sympathy and respect for these Sons of Martha.

While this dissertation is not an attempt to argue about who the “real” Sons of Martha might be, it does represent a concerted effort to demonstrate the inherent interdisciplinarity, or
“mutual dependency,” as Miller calls it, of the children of Martha and Mary. As Miller (1991) writes,

A corrective good story…, like new feminist versions of women, depends on including characters and their ordinary daily actions in the symbolic domain that traditionally marginalizes them, denying their significance in symbolic as well as factual “reality.” A revised account requires that we endow agency and dignity on its protagonists by making them “relevant” to contexts we already find greater than the sum of their parts. (p. 3)

By examining the engineering of literacy at the level of individual actors, daily actions, and everyday texts, this dissertation endeavors to provide just such a revised, agentic, feminist account of engineering enculturation and the practice of discipline.
A key problem in the study of disciplinarity is the negotiation between numerous, often competing methods that prior researchers have used to study activity, identity formation, and social processes in disciplinary contexts. Indeed, the existing methodological apparatus is large and there are multitudes of studies and contradictory models to follow. But, for those who take Bakhtin (1981; 1986) to heart, the endeavor to replace or displace previous models is not particularly worthwhile, as any “new” model will necessarily blend the frameworks that have come before. Indeed, Bakhtin’s (1986) notion of utterance suggests that actions in the present draw on and are responsive not only to the past, but also to the present and future:

The very boundaries of the utterance are determined by a change of speech subjects. Utterances are not indifferent to one another, and are not self-sufficient; they are aware of and mutually reflect one another…the utterance is related not only to preceding, but also to subsequent links in the chain of speech communication. (pp. 91-94)

Even more importantly, for Bakhtin, as for Whitman’s narrator in “Song of Myself,” the past is configured less as a unified history than a messy collision of overlapping and contradictory
pasts, deployed chronotopically to create synthetic realities. As Bakhtin (1986) explains, “Even past meanings, that is, those born in the dialogue of past centuries, can never be stable (finalized, ended once and for all)—they will always change (be renewed) in the process of subsequent, future development of the dialogue” (p. 170).

Thus, while this dissertation does aim to synthesize a new model of disciplinary enculturation, it does so with an eye to this dialogic past. As I write, I have tried to resist the urge to artificially harmonize inharmonious models. This is for at least two reasons. Firstly, some coexisting models simply cannot accommodate each other; perhaps one requires that a particular sphere of activity be at the forefront, while another insists we consider an entirely different set of coordinates. To argue for the primacy of one of these models over another would be to willingly ignore a part of the action, moving away from a Bakhtinian view of the past as unfixed and unstable.

My second reason for embracing multiple models, especially when they are incongruent, concerns my effort to reimagine what it means to be rigorous. To pursue rigor, I believe we must engage in what Haraway (1991) refers to as irony: “Irony is about contradictions that do not resolve into larger wholes, even dialectically, about the tension of holding incompatible things together because both or all are necessary and true” (p. 149). In order to be rigorous, we must resign ourselves to the existence of paradoxes, to allow for incongruities, and to actively struggle with several contradictory ideas at once. The methodological payoff will be a fuller, more comprehensive picture of how people are made, how we become disciplined, and how, in turn, we make the disciplines. With Haraway and Bakhtin in mind, the disciplinary pasts that lead up to the present study are unapologetically heteroglossic, laminated, and contradictory.
Theoretical Foundations and Disciplinary Pasts

Canonicity  In contrast to biological and social sciences, engineering—the discipline at the heart of this dissertation—seems to be socially recognized as a predominantly white, male field. This is true if one judges by what Anscombe (1958) calls the “institutional facts.” The National Science Foundation’s (2007) statistics most recent report shows that six times as many men (17.9%) as women (2.9%) enter an undergraduate program with the intentions of majoring in engineering.¹ And despite the vigorous recruitment efforts of the NSF and engineering universities, the numbers also suggest that female and African American enrollment in undergraduate engineering degree programs has been persistently decreasing since 2000.² On the other hand, if one were to judge women’s involvement in science and engineering-related fields by what Anscombe (1958) refers to as the “brute facts,” a very different impression might emerge.

Traditionally, researchers (like those at the NSF) have used institutional facts to map out networks for the discipline of engineering. These networks include public and private institutions, students, teachers, professionals, and workplaces. But what if the material-semiotic map of engineering engaged a network of a particular, smallish group of engineers? There are in fact many of these such groups on the internet, such as Women in Science and Engineering (WISE), The Association for Women in Science (AWIS), Women Tech World, South African Women in Engineering, and Aboriginal Women in Science. If we were to trace out engineering networks via such web presences, we would find numerous success stories from women who have passed through engineering school and become accomplished professionals. Another

¹ http://wwww.nsf.gov/statistics/seind10/c2/c2s2.htm#s3
² ibid
feature of these web communities is the proliferation of lists of notable “Female Firsts,” like Marie Curie’s isolation of radium, Hazel Bishop’s discovery of the first long-lasting lipstick, Emily Roebling’s work on the Brooklyn Bridge, or Martha Coston’s invention of maritime signal flares. Reading these online networks as efforts to remap scientific and technological history, the canons are redrawn as neither exclusively male nor exclusively white. More than merely adding to the old, predominantly male canons, these remapping efforts have the power to change what we imagine engineering to be.

Rigor vs. Objectivity In some scientific realms, objectivity seems to hold an almost religious significance. Scientific disciplines have a history of associating rationality and objectivity with good science practice. And yet scholars of science studies (e.g. Markley, Haraway, Gould) have found that objectivity is often more an ideal, an idea, than an actuality. Rigor, which we can take to mean objectivity-in-practice, is fraught with all sorts of complicating factors: desire, bias, error, faith. Modern-day notions of rigor, for instance, were born in the unmistakably religious Royal Society of England, established in 1660. Markley (1983) discusses the parallel narratives of religion and science, showing that for both Robert Boyle and Isaac Newton, rigor was rooted in a need to praise God:

Their attempts to connect methodology and teleology—central concerns in both men’s voluminous writing—are ultimately ideological, psychological, and historical efforts to articulate and control the implications of scientific objectivity. At best, Boyle and Newton reach provisional conclusions that objectivity is the reflection—or perhaps the interruption—of faith in—or into—the practice of science. (pp. 356-357)

In this sense, science and religion are not dissimilar. Both science and religion consist of a set of
theoretical ideals along with a history of practice. The procedures of science resemble the rituals of religion: activities that were once direct enactments of ideals, but have become abstracted and dissociated over time. Much of modern mathematics, as Markley notes, is the result of Newton’s desire to praise God in the purest language he could devise.

George Santayana was not a religious man, but an atheist poet and philosopher who felt religion had a deep aesthetic value. In *Sonnet III*, Santayana shows his reverence for faith: “O World, thou choosest not the better part!/It is not wisdom to be only wise,/And on the inward vision close the eyes,/But it is wisdom to believe the heart” (1917; p. 270, lines 1-4). When scientific knowledge offers only a smoky haze, barely illuminating the path ahead, faith sheds “a tender light” (lines 9-12). Santayana’s poem is strikingly spiritual in tone; so spiritual, in fact, as to call into question his atheism. How can an atheist see faith as “invincible,” much less approve of this unwavering confidence in “the thought divine?” Is his piety merely an affectation, a literary trope? Santayana’s (1923) great philosophical tome, *Scepticism and Animal Faith*, sheds some light on his reconciliation of faith and critical thinking. There is more to consciousness than rationality, he explains. Animal faith is a conception that does not privilege human nature over animal instinct. The feelings and natural attitudes that sustain us are due to faith, not reason, he says, and this is part of our being animals. We are animals first, scholars second, and though we may be capable of skepticism, our animal faith is the glue that holds us together.

To take for granted the neutrality of any field is a precarious endeavor, for our desire for “pure” rationality is no match, like Santayana (1923) says, for our instinct toward faith. Faith leads to preference, and to bias. In *The Mismeasure of Man*, Gould (1981) writes,

Impartiality (even if desirable) is unattainable by human beings with inevitable backgrounds, needs, beliefs, and desires. It is dangerous for a scholar even to
imagine that he might attain complete neutrality, for then one stops being vigilant about personal preferences and their influences—and then one truly falls victim to the dictates of prejudice. (p. 36)

Unlike objectivity, rigor allows for some means of calling older ideas into question. Scientific paradigms must eventually be replaced by more accurate and/or more comprehensive paradigms. Ideas can outlive their usefulness, and new and conflicting data should not be considered garbage merely because it might disprove an idea previously thought to be true.

In the “Cyborg Manifesto,” Haraway (1991) lays out what I see as a feminist version of disciplinary rigor, which she calls “blasphemy” and sometimes “irony” (p. 149). In the years leading up to her publication of the Manifesto, Haraway had become increasingly concerned with the pattern in feminist discourse of condemning all criticism of feminism as anti-feminist. She worried that feminists were ignoring the value of constructive critique in favor of putting forth a falsely unanimous front. For instance, women of color who called into question the anglo-centrism of the first and second waves of feminism were sometimes accused of undermining the feminist project. The Manifesto is Haraway’s response to her growing dissatisfaction with the power of the feminist “moral majority within” (p. 149). Blasphemy, she writes, “has always seemed to require taking things very seriously...[it] is not apostasy, [but] a rhetorical strategy and a political method, one I would like to see more honoured within socialist-feminism” (1991; p. 149).

For Haraway, the cyborg is the mechanism for blaspheming her faith. The cyborg, a remote, androgynous hybrid of human and machine, simultaneously forces the community to recognize its religious faith in itself as well as the paralysis this faith is causing, and in so doing,
reanimates, restores motion to the community. Of course, she is speaking about the community of socialist-feminism, not disciplinary studies, but the idea generalizes.

It would be an exaggeration to claim that irreverent research is done only by women, or that all women researchers are interested in playing with or breaking from disciplinary standards. However, the irreverent research stance can be seen as a feminist take on the notion of scientific rigor. Both blasphemy and objectivity are as much a position of serious investment as they are of defiance. However, blasphemy has at least one significant advantage. If we compare Haraway’s “blasphemy” with, for instance, Gould’s (1996) discussion of rigor, we see that while blasphemy is an ironic, playful stance, overreliance on objectivity is the scientist’s tragic flaw. “Only scientists” writes Gould, “are arrogant enough to think that they always observe with rigorous and objective scrutiny, and therefore could never be so fooled—while ordinary mortals know perfectly well that good performers can always find a way to trick people” (p. 37). Unlike objectivity, blasphemy allows, as Haraway (1991) says, for “contradictions that do not resolve into larger wholes,” and rather than replacing old ideas with new, it encourages us to try to hold “incompatible things together because both or all are necessary and true” (p. 149).

Gould talks about resolving personal preference in scientific inquiry, coaching his colleagues to acknowledge their own latent biases as he has.

We deny our preferences all the time in acknowledging nature’s factuality… I really do prefer the kinder Lamarckian mode of evolution to what Darwin called the miserable, low, bungling, and inefficient ways of his own natural selection—but nature doesn’t give a damn about my preferences, and works in Darwin’s mode. (p. 37)

Though he speaks in the first person, Gould addresses the reader-scientist, telling him or her to
confess to his or her preferences and thereafter continually reevaluate these preferences whilst producing new knowledge. In order to advance a field meaningfully and self consciously, one must be willing to point out when one’s community has gone astray, to see the flaws in one’s chosen approach, to recognize one’s inherent biases. Though we can never be truly objective, we can attain a measure of rigor in this way.

**Representation and Simulation** Efforts to reconstruct a history are also necessarily constructions of that history. Put another way, by foregrounding certain problems and highlighting one particular achievement instead of another, historicizations construe history differently and for different purposes. This is what makes literature reviews such necessary and telling components of any new contribution to an old field; in raising rhetorical questions about the history of that field, a literature review also inevitably demonstrates how the author sees his or her own disciplinarity and where he or she would like his or her field to be going.

That said, to my mind, the most salient (though not the most accurate) representations of twentieth-century disciplinarity are C.P. Snow’s “two cultures” (1959) and Swales’ (1990) notion of “discourse communities.” Snow’s infamous lecture, which dealt with the growing schism between the sciences and humanities, drew attention to the divergence in disciplinary values and discourses; the lecture was, in fact, so inflammatory that he is still being criticized for exaggerating the differences between the knowledge and textual production practices in the humanities and hard sciences (Boulding, 1967; Becher, 1989). Similarly, Swales’ (1990) version of “discourse communities” seeks to depict discursive distinctions between different disciplinary groupings. Moreover, like the “two cultures,” discourse communities have been problematized for obstructing contextualized understandings of disciplinary practice (Faigley, 1986; Pratt, 1987; Harris, 1989; Prior, 2003). And yet both Snow’s and Swales’ representations,
though problematic, are incredibly pervasive; both are still active models for understanding how disciplinary communities work. This persistence seems to point to a desire for clear-cut, straightforward research models. For why else, if they are so flawed, have they persisted?

Scholars have since offered up more situated and detailed accounts of literate activity, disciplinary participation, and enculturation. For instance, Engestrom’s (1987; 2007) “activity systems,” Lave & Wenger’s (1991) “communities of practice” and “legitimate peripheral participation,” Gee’s (2004) “affinity spaces,” Becher’s (1989) “academic tribes and territories,” and Spinuzzi’s (2002) “genre ecologies” each represent a different way of understanding and researching disciplines and disciplinarity. Though each of these heuristics have offered new and useful frames for understanding literate, disciplined activities, and are considered by many to be improvements upon their simpler predecessors, most have met with at least some resistance.

Rock (2005) criticizes communities of practice for encouraging disingenuous labeling, and Lea (2005) suggests that legitimate peripheral participation is too often used as a top-down educational model. Prior (2003) worries that activity triangles are just as susceptible to structuralist misappropriations as any other abstract term. As abstract representations, affinity spaces, tribes and territories, and genre ecologies, are also vulnerable to critique, not because they are flawed but because they are representations. As Bakhtin (1981) explains, “The represented world, however realistic and truthful, can never be chronotopically identical with the real world it represents” (p. 256). Or to paraphrase Derrida (1978), representation will always run the risk of “killing” (obscuring and/or replacing) the object of representation:

Representation is death. Which may be immediately transformed into the following proposition: death is (only) representation. But it is bound to life and
to the living present which it repeats originarily. A pure representation, a
machine, never runs by itself. (p. 227)

**CHAT and ANT** Indeed, even when the oversimplicity of representation is not a
problem, disciplinary machines can forestall dovetailing interests, making combinatory paths of
inquiry tricky to negotiate. While researchers from many fields have been working to
understand the literate practices of professional scientists and those in training (Latour, 1987;
Bazerman, 1988; Myers, 1990; Berkenkotter & Huckin, 1994; Knorr-Cetina, 1999; Suchman,
2000), they have frequently done so under very different disciplinary banners. For instance,
uptakes of cultural-historic activity-theory or CHAT (Volosinov, 1973; Vygotsky, 1978; Cole,
1985; Bruner, 1986; Engestrom, 1987 & 1993; Wertsch, 1991) engage a matrix of histories,
trajectories, affordances, artifacts, and tool mediation as a means for understanding behavior,
development, and internalization.

Actor-network theorists like Bruno Latour, John Law, and Michel Callon pursue many of
the same practices and practitioners, sometimes with similar conceptual tools. Artifacts (or non-
human actors) and distributed activity have important places in both CHAT and ANT. Both
perspectives are also concerned with mediation: while CHAT considers the ways in which tools
mediate actions and operations, ANT endeavors to distinguish intermediaries (components that
do not mediate activity) from mediators (components that do mediate activity). Though
different, these two approaches have, in practice, shared an appreciation for seeing activity as
complex, contextual, and dialogic. Indeed, CHAT and ANT seem so compatible that they are
sometimes conflated and/or concatenated (see for example the definition of CHAT in Prior et
al., 2007).
One of the key differences between the two theories is that CHAT conceives activity hierarchically (goals govern actions, conditions arbitrate operations) while ANT is “flat”: all actors and actants are on the same level and can all potentially shape (or be shaped by) one another. Another important distinction, which Miettinen (1997, 1999) has made, is that CHAT is dialectic (components of the system are defined in relation to each other), whereas ANT is symmetric (all components are described with the same semiotic terms). A third, significant point of departure is that ANT tends towards apoliticism, which poses a moral issue for some researchers, like Lemke (2000) who criticizes ANT for eschewing the influence of politics on material-semiotic networks; “Meaning is the link between matter and history; making the material meaningful potentially links the scale of humans, artifacts, and other same-scale ecological partners to the larger scales of their diverging histories and the dynamical processes that determine those histories” (para. 39). But for Latour (1999), who has elsewhere written extensively on ontological politics, this political “flatness” represents an untapped potential of the ANT framework, “especially the political implications of a social theory that would not claim to explain the actors’ behaviours and reasons, but only to find the procedures which render actors able to negotiate their ways through one another’s world-building activity” (p. 21).

This dissertation is also an experiment in putting ANT and CHAT into conversation with each other. The goals of this experiment are many. For one, it responds to the growing curiosity3 about the extent to which ANT and CHAT are reconcilable. Furthermore, it is an

---

3 Engeström and Escalante (1996) were among the first to consider what ANT might be able to contribute to CHAT, but do not yet seem convinced of the efficacy of such a pairing (see also Engeström 1999). Russell (1997) has also considered the potential value to genre studies of “activity networks,” a spin-off of current notions of activity systems that highlight the dynamism and flexibility of Latour’s rhizomatic approach. Prior (2008) has recently proposed a kind of synthesis of (hierarchic) cultural-historic activity approaches and (rhizomatic) actor-network
exercise in the kind of reimagined rigor that I described in the beginning of this chapter (in other words, it asks the question “Can holding two conflicting models as simultaneously true contribute to a more comprehensive, or ‘honest,’ understanding of messy activity?”). In other words, I aim to find a robust means for studying collaborative practices and technopolitical networks while avoiding the trap of those comfortable, irresistible *a priori* notions. It is out of a desire for rigor that I turn to feminism and Foucault, perhaps the two most powerful tools for destabilizing institutional(ized) logic.

**Feminism and Foucault** One of the strengths of Foucault’s approach (especially in 1972 and 1975) is his work on the destabilization of what he calls *unities*. What he (1972) urges us to recognize is that these unities, though they seem almost tangibly true, are actually deceptive; if we only look at the present state of an institution, we ignore the changing, shifting, discontinuous nature of institutions; and this ignorance damages our ability to destabilize. For instance, if we attempt to dismantle an institution by extricating ourselves from it, we fail before beginning, for we have unknowingly reinscribed the institution in our attempt to “escape.” There is no “outside the institution.” In this way, Foucault sensitizes us to the underlying power structures that temper our interpretations of the world. His approach to destabilization requires the careful examination of how an institution socializes people over long periods of time (such as the prison or the notion of sexuality). In creating this kind of dis-unifying history, we can better understand how institutions function, including the surreptitious shifts and discontinuities.

This Foucauldian approach of hunting out those hidden, underground networks bears strong resemblances to Deleuze and Guattari’s (1987) notion of the rhizome (and to the perspectives, which he has referred to as “flat CHAT,” and Spinuzzi (2008) is also pursuing alternative ways of blending ANT and CHAT.
rhizomatic view of activity in ANT, which is adapted from Deleuze and Guattari’s notion). Deleuze and Guattari, contemporaries and friends of Foucault, used the rhizome as a trope to evoke the connectivity of institutions; they write, “any point of a rhizome can be connected to anything other, and must be…” (p. 7). More importantly, Deleuze and Guattari’s rhizome is infused with the power to disturb unities (which they also call pseudomultiplicities) by demonstrating the interconnectivity of seemingly isolated things; “Multiplicities are rhizomatic, and expose arborescent pseudomultiplicities for what they are. There is no unity to serve as a pivot in the object, or to divide in the subject” (p. 8). In other words, rhizomes help us to see how assemblages are made, remade, and related to other assemblages.

Feminism, like Foucauldian theory, is dedicated to exposing the power structures that function as agents of socialization and indoctrination, but unlike Foucault, is also concerned with the impacts of marginalization on the everyday lives of individuals (de Certeau, 1984). Jarratt (1998) conceives feminist research as the struggle “to transform disciplinary knowledge by pointing out its ideological investments, particularly investments that sustain oppressive social structures and relations of economic exploitation” (p. 2). In this way, feminist theory articulates the stakes of the project of destabilization; if we do not attempt to expose institutional oppression and marginalization, we are complicit in those activities. Moreover, if we attempt to expose oppression using structuralist approaches, we risk undermining our efforts. Richardson (1997) for instance, describes her realization that her effort to position her feminist work in sociology as “outside” or “against” the mainstream ideology had the unintended effect of “displacing the power and centricity of my own ‘current’” (p. 174). It is for this reason that Jarratt, who co-locates the projects of feminist research and composition studies, warns against
operat[ing] to calcify what should be liquid, mobile, and malleable, what should be constantly reshaped in synchrony with the changing lives of students. [We] need mobility to respond to systems of power, which, paradoxically, appear immovable yet are constantly adjusting themselves to keep in place a status quo...

(p. 3)

Feminism trains us not only to recognize certain institutional unities, but also to see how such powers render some people as insiders and others as outsiders. Jarratt importantly locates “the changing lives of students” as the nexus for destabilization projects; only by examining the lived lives of individuals can we hope to grasp the key component of the rhizomatic network: the truths of everyday experience. Haraway’s (1988) concept of “situated knowledges” also argues for the value of studies of individual, embodied, physical experiences. Yet within this project of hierarchical destabilization, within the stories of individual disciplinary experience that comprise the bulk of this dissertation, I find that there is much about which to be hopeful. If I engage a critical (feminist, Foucauldian) perspective to problematize the ways in which others have (mis)conceptualized disciplinarity (i.e. discretely, conservatively, conventionally), my stance towards my participants is generally sympathetic.4

Serious Play Play has become a particularly convenient lens for this dissertation due to its multiple senses. One common reading of the term is children’s play, which can connote unseriousness, entertainment, and dalliance, but from the perspectives of Piaget and Vygotsky, also functions as essential scaffolding for adulthood. In fact, Rieber, Smith, and Noah (1998) and Eglash et al. (2004) suggest that adult play (or “serious play”) is not so different from

4 Exceptions discussed in “Personal Resonances” in the conclusion.
child’s play, insofar as adults experience emotional investment, fascination, and even time loss when truly engaged. Play is also a component of cognitive imagination, as shown by Wartofsky’s (1979) “tertiary artifacts” of “non-practical play,” which connect the physical world with our conceptual models. Goffman’s (1959) dramaturgical sense of the word play (e.g. participation as role-play, social life as performance) adds a sociological dimension that has since resonated with many scholars. Play might also connote manipulation: to “play on his weaknesses” or “play with her emotions,” but the two connotations that are perhaps most apt for this dissertation describe a literal looseness (e.g. in a piece of machinery) allowing space for movement and the figurative flexibility that permits room for interpretation.

As Richardson (1997) reflects on her personal and professional experiences as a sociologist, she frequently turns to images of play.

When I was a child, I liked to play Hide-and-Seek. Two or twenty could play.
Boys and girls of all ages played together…Inside and outside we played.
Houses, alleys, backyards, and the woods were all game sites. The boundaries were drawn and redrawn, never quite fixed. Hiders became seekers; seekers, hiders. Roles were interchangeable…it was about being together with others, but on my own, alone, deeply experiencing both existential estrangement and social dependence. (p. 25)

Play emerges as the key metaphor she has lived by, a metaphor we might refer to (à la Lakoff & Johnson, 1980) as RESEARCH IS A GAME. In the above excerpt, an especially salient example of this RESEARCH IS A GAME analogy emerges, where Richardson likens the investigative experiences of her adult life to childhood games of Hide-and-Seek.

The analogy may not resonate for all readers; perhaps it appears overly glib. To be sure,
our serious and cerebral conceptions of academic research are in many ways the inverse of the perceived silliness of children’s play. However, as Eubanks (2000) has shown, sometimes even a synthetic analogy can be productive if it shows us something in a new light. I use the word “synthetic” to indicate those analogies deliberately constructed (e.g. RESEARCH IS A GAME), and to distinguish them from the canonic ones that develop slowly and over time, those that evolve from (and into) cultural values. Eubanks’ study found that research participants willingly considered synthetic analogies, using what he calls “licensing stories” to determine the extent to which the analogies hold semantic value. We might abstract from this study that metaphors are more flexible than they appear, and certainly more flexible than they seemed to Lakoff and Johnson in the 1980s. We might try out a licensing story with RESEARCH IS A GAME.

On the other hand, if one tries to make a licensing story in the other direction, i.e. PLAY IS RESEARCH, one is immediately struck with the canon of researchers who would wholeheartedly embrace this analogy. Theories of play have a long history of use in the interpretation of human behavior, particularly in cognitive linguistics and psychology and the work of Piaget and Vygotsky, who situated play as a universal stage (or series of stages) of the cognitive development of children. Play serves as the scaffolding of development: in play, Vygotsky (1978) writes, “a child’s greatest achievements are possible… achievements that tomorrow will become her basic level of real action” (p. 100). Sure enough, children’s play can be serious, conceptual, problematic, and systematic. It is exploratory and experimental. It is, in other words, very much like research.

---

5 In what sense is research like a game? Does research ever feel playful? Does it ever feel trivial? Or instinctive? Or mischievous? What do our notions of play do when we put them face to face with our ideas about what research is (or should be, or should not be)? For contrast, consider licensing stories with metaphors like RESEARCH IS WAR or RESEARCH IS TORTURE. Thinking of one’s research as play has its advantages.
Stepping back for a moment, analogies of the form X IS A GAME comprise an interesting class of metaphor, at the very least because of the number of theorists who have explored the ways in which games are like things that are not games. Santayana (1896) troubles the play/work binary, which he felt cast play as “essentially frivolous,” arguing instead that play was a crucial component to our evolution into big-brained mammals capable of higher thought (p. 26). In Santayana’s view, PLAY IS WORK. Play is also at the heart of Wittgenstein’s (1953) notion of human language. His “language games” cast human interaction as play; he believed that these games formed families and that these families explained how we use language: by grouping texts according to similarities, or “family resemblances” (§65-67). For Wittgenstein, LANGUAGE IS A GAME. Many others have also reflected on play’s relationship to higher level thought and action (Huizinga, 1971; Geertz, 1973; Wartofsky, 1979; Spariousu, 1989; Perinbanayagam, 1991), including some who have considered the appropriateness of comparisons to specific games such as rugby (Serres, 1982), tennis (Freadman, 1987), and chess (Casanave, 2002).

Richardson’s analogy also distinguishes itself by calling attention to the sexuality and genderedness of social play and, by the commutative property, of academic work. More than anything, the analogy sheds light on what it means to be a woman in academia. Her academic collaborations are like romantic trysts: gratifying, enthusiastic, at times tempestuous. She says that she played the field, resisted commitment, refused to settle down, and as a result was regarded by some with suspicion and reproach. The irreverence of the metaphor is more than a mere convenient coincidence. From Richardson’s perspective, the only (good) way to survive as a female academic is to do so with irreverence, by seeing one’s work as play. Though Richardson may be the first to evoke gender with the play analogy, the same call for irreverence
echoes throughout the work of many women in the academy, from the hard sciences (Emmy Noether, Barbara McClintock), to the social sciences (Margaret Mead), and the humanities (Hannah Arendt, Helene Cixous, G. E. Anscombe).⁶

Methodology

Research Questions How does an Engineering student become an Engineer?

Research in a variety of disciplines and professions has shown that this process is complex and that various forms of writing (along with associated means of thinking and communicating) are central to this process. The study that this dissertation reports on was designed to investigate the relationship between teaching and other facilitative practices in Engineering departments, writing and other communicative practices, and students’ disciplinary identities. I was interested to learn more about student, faculty, staff, and administrative beliefs about what it means to be an engineer, what knowledge is foundational, and what constitute the “best practices” of a teacher, learner, or worker in engineering.

My project aimed to investigate existing educational practices (particularly those related to written and communicative instruction) in engineering, with special attention to classes for engineering majors and extracurricular activities designed to support students’ engagement with engineering. Overall, the project explored the range of teaching, learning, and working practices in use at UIUC. I also pursued in more depth a subset of courses to learn how instructors and students were employing writing and communication as they developed shared understandings of what it means to be an engineer.

⁶ We might even look all the way back to ancient Alexandria, to the teachings of the female mathematician Hypatia, who was allegedly killed by Catholic mercenaries for her (literal) irreverence.
My key research questions included:

1. What does it mean to be an engineer, and how does one become an engineer?
2. How does one teach or help someone to become an engineer?
3. What roles do writing and communication play in this enculturation?

**Participant Recruitment** With the aim of sampling a wide variety of views within engineering, I identified a number of courses, offices, and classroom organizations (small and large classes, laboratories, and extracurricular organizations, etc.) at UIUC. I began by requesting participation from instructors of courses and organizers of clubs to provide accounts of their perspectives of the engineering discipline. I then requested participation from students in the classes, clubs, and organizations. I did some additional recruiting by placing a call for participants in the RSS newsfeed on UIUC’s engineering webpage, in the free engineering magazine published at UIUC, and on public sign-up sheets in engineering buildings on campus.

My goal was to include a large number of students, staff, and instructors to ensure that participation was both diverse and representative. My only criteria for participants was that they be involved in an identified engineering class, organization, faculty, or office and that they be willing to participate. After hearing my verbal description of the project or reading a text summary, all potential participants were able to self-select whether to not they wanted to participate. I advised all participants that their participation or non-participation was voluntary, that it would have no bearing on their evaluations in their course of study or work, and that they were free to withdraw from the study at any point without penalty.

**Data Collection and Analysis** The first phase of the research included a qualitative
inventory of engineering teaching and learning practices in a variety of settings and from diverse sources: departmental and course websites, syllabi, writing prompts, individual papers, departmental requirements, class notes, application forms, digital and paper materials generated for engineering clubs and organizations, and so on. Given my literature review and personal experiences, I anticipated a wide variety of genres, media, and “best practices.” This first phase also included an examination of course documents, short interviews (to obtain basic data on engineering practices, their purposes, and their contexts), identification of extracurricular programs designed to support the learning and/or teaching of engineering, collection of documents (print and electronic), and in some cases audio- or video-taped records of interactions. I then partially transcribed and coded these interactions and analyzed them to produce a broad sense of engineering practice across a range of undergraduate and graduate programs, extracurricular programs, and instructor and staff facilities.

My initial inventory, which covered approximately twenty engineering clubs and courses, was meant to be sufficiently detailed to produce a meaningful portrait of engineering at UIUC: to understand not only what kinds of classes are offered here, but also how they are taught and administered, what kinds of writing and other communicative practices students engage in around (and in addition to) these courses, and why (disciplinary histories, received genres, impact of faculty development activities) those practices are used.

Overall, I conducted semi-structured and stimulated elicitation interviews with eight instructors, three administrators, three staff members, and twenty three students. While I anticipated that interviews would last between 30 minutes and an hour, participants were often eager to speak for even longer, which occasionally necessitated additional subsequent meetings. The average duration of the interviews was approximately 68 minutes. In the semi-structured
portion of our interviews, I asked participants to discuss engineering practices in their course, organization, or office, including the perceived purposes, benefits, and drawbacks. For the stimulated elicitation portion of the interviews, participants presented me with course, workplace, and club-related documents they had authored, and reflected on the meanings, purposes, and consequences of the texts in relation to the study’s key research questions.

**Identifiability** In the interest of preserving the participants’ authorial rights and intellectual property, I did not collect data anonymously. Much of the data was related to classroom and programmatic activities that were already quasi-public. I did inform participants of ways that their data might be identifiable and collected data in ways that supported confidentiality. For example, I conducted the majority of interviews in offices where others were not present and requested permission to identify participants by name in reports on the research. Although I anticipated using pseudonyms for most students' interview comments and materials, I found that many students were enthusiastic to be identified by name so that they would get credit for their ideas.

**Overview of Remaining Chapters**

Chapter 2 explores the texts of a broad swath of engineering students, considering the extent to which novice-expert and insider-outsider demarcations begin to fail when we look at individual knowledge production practices. While traditionally configured as novices, we can see from these students’ texts and talk that they are already quite savvy.

Moving from the words and ideas of students to those of the “experts,” Chapter 3

---

7 Excerpts appear throughout the text of this dissertation, some of which I have made available in fuller form in the appendices.
contemplates the activities of teachers and established researchers of engineering. In stark contrast with beliefs about the rigidity of technical enculturation and the austerity of the engineering canon, the lived experiences of engineering teachers and researchers indicate a fascinating degree of playfulness. Rather than being a distraction from disciplinary practice, play emerges as a constitutive force.

Extending Pickering’s metaphor of the “mangle of practice,” Chapter 4 delves into a parallel engineering world, considering the acculturative context of another engineering university in the same time period but in a very different physical space. While this world illuminates much about the situatedness and un-generalizability of disciplinarity across space and time, it also provides clarity on the local University context. Moreover, while Pickering’s “mangle” succeeds in highlighting the messy unpredictability of engineering enculturation, this chapter also demonstrates the ways in which the “mangle” breaks down, failing to capture the irreversibility of what Prior and Shipka (2003) call “chronotopic lamination.”

Finally, while raced, classed, gendered, and queered bodies are routinely absent from disciplinary models, Chapter 5 both retrieves these embodiments and demonstrates how ostensibly idiosyncratic practices index volumes about disciplinary cultures. During interviews, participants routinely indexed emotionally-charged issues—race, gender, class, faith, and sexuality—in connection to their enculturation into and continued participation in engineering. Moreover, these cases suggest that some of the most consequential texts are off the disciplinary map. In addition to the canonical disciplinary texts typically captured in studies of disciplinary (e.g. lab and research reports), participants in this study referenced and provided samples of numerous other kinds of texts critical to their practice of engineering. Through this alter-canon—mission statements, resumes, application forms, novels, religious texts, and
poetry—we see how poorly our maps of engineering represent literate life.

As my ethnographic evidence has increasingly called into question traditional classification schemes, I have begun to formulate a new framework to complicate the mapping of disciplinarity. This framework, which I call “home discipline,” traces literate disciplinary practices beyond traditional academic sites as well as manifestations of idiosyncratic “nondisciplinary” practices within such institutional spaces. In taking individual talk and text as key levels of analysis, such research reveals the extent to which seemingly distinct disciplines have always been laminated networks of activity populated with many unruly texts, spaces, and human beings.

In this way, I engage ANT, CHAT, Foucault, feminist theory, and philosophies of canonicity and rigor to navigate the rhizomatic messiness of engineering while also staying alert to its hierarchies, institutions, and individual subjectivities. This modified Flat CHAT approach traces the disciplinarity of engineering through key historical moments as well as in everyday experience, incorporating ethnographic and archival evidence, and juxtaposing the enculturation trajectories of engineers with disciplinary norms. In so doing, I work to show that trajectories are disjoint and discontinuous more often than not and that disciplinary boundaries are dynamic; not only are individuals continually in flux, so too are canons, boundaries, and disciplines. Ultimately, I argue that this approach to disciplinarity can help researchers to problematize structural, depoliticized conceptions of disciplinarity and to discover more nuanced, feminist ways of understanding enculturation.
Chapter Two: Exceptionally Disciplined

The problem that confronts us when we try to compare the structure of discourse and explanation in different domains of knowledge is that no one is an insider in more than one field and insider information is essential.

R.C. Lewontin

So begins Lewontin’s 1991 article, “Facts and the Factitious in Natural Sciences,” a treatise on variations in understandings of the word “fact” in the fields of science and history. As his piece argues explicitly for a conception of natural facts as constructs, it also captures Lewontin’s ambivalence towards his own disciplinarity and his struggle to both critique and defend that territory. As a trained and publishing biologist, Lewontin banks on his possession of insider information of biology to convince his readers that all facts are indeed manufactured, regardless of disciplinary context. Interestingly, his readers are sure to be mostly humanists, as “Facts and the Factitious” was published not in a journal of natural science, but in Critical Inquiry, an academic journal for critical analyses of the literary arts. The very fact of a scientist having a humanist readership would seem to complicate Lewontin’s premise that being an insider in one field consigns one to outsider-ness in all other fields. Even if publication within disciplinary journals is not a sufficient measure of a writer’s insider status, it does seem to rule out the

---

possibility of the author’s being a total outsider, especially when the article is published in earnest.9

Lewontin is certainly not the only person to use “insider information” as a designation for disciplinary membership; consider, for instance, Swales’ (1990) conception of discourse community in relation to, among several other criteria, membership threshold: “a suitable degree of relevant content and discoursal expertise” (p. 27). Just as Lewontin’s model implies the “factitiousness” of certain fixed parameters —“insiders,” “outsiders,” “essential information”— so does Swales’ conception cast ideas like “lexis,” “relevance,” and “expertise” as precise measures of disciplinarity. Corpus linguistic study, many of which draw on Swales’ work, supports such metrics of disciplinary language varieties. Recent corpus-based studies of scientists (Hyland, 2004; Samraj, 2004; Rowley-Jolivet & Carter-Thomas, 2005; Biber, 2006) allow for, as Bawarshi and Reiff write (2010), “using large scale electronic text databases or corpora…to conduct systematic searches for linguistic features, patterns, and variations in spoken and written texts” (p. 38). Such studies can succeed in representing language varieties that students and faculty engage in during the course of enculturation. However, this kind of work also depends upon very clear, discrete notions of what constitutes a “microbiology text”, “physics text”, or “scientific text”. This chapter considers how easily texts fall into such disciplinary categories, as well as the extent to which such designations enable us to understand the process of enculturation.

All this to say, if Lewontin does not fit into his own model of discrete disciplinarity, perhaps it is because no one does. Models like Foucault’s (1972) “archaeology of knowledge,” Crane’s (1972) “invisible colleges” and Klein’s (1990; 1993) “interdisciplinarity” complicate the

corpus linguistics’ (as well as Lewontin’s and Swales’) discrete, orderly vision of disciplinarity. For Crane, learning happens by way of a kind of “diffusion process,” wherein scientific knowledge is spread by the infected to the uninfected rather than by experts to novices (1972; pp. 22-26). Crane’s playful disease metaphor underscores her overall model of enculturation as collections of small practices, many of which are under the radar, which come together, signify, and enact “invisible colleges.” Ultimately, for Crane—as well as for Foucault (1972)—these ad hoc formations are clearer and more accurate representations of disciplinary learning, practice, and change. Alternatively, Klein’s model (1993) highlights the spontaneous ruptures—rather than the cohesions—in disciplines as the key mechanism of disciplinary enculturation: “Because discipline has been the dominant category in studies of knowledge, permeation is usually undervalued or even dismissed as a peripheral or extradisciplinary event” (p. 186). On the contrary, Klein argues, “Permeation occurs across the distance of discipline, from frontier to core” (p. 187). Thus, while Klein takes up some of the same constructs as Swales and Lewontin—periphery, frontier, core—her uptake is not hierarchical, suggesting a flatness or uniformity in disciplinary permeability and blurring across multiple levels of expertise.

In this chapter, I consider the applicability of these models and constructs to everyday people in the College of Engineering, particularly those who would normally be classed as “novices” by more conservative models of disciplinarity. Using the blended theoretical framework described in the previous chapter, with tools from sociohistoric discourse analysis (e.g. Cole, 1985; Wertsch, 1991; Russell, 1995; Engeström, 1999) and actor-network theory (Callon, 1986; Latour, 1987; Law, 1991; Callon, 1999; Latour, 2005) I seek to make sense of ideas like “core,” “canon,” “expert,” and “outsider,” in relation to the lived and textured experiences of these so-called “novice” participants. As illustration, I present some of their
engineering texts and consider the texts in relation to participants’ talk about their learning and production practices. Through these artifacts, I begin to construct a new model of local engineering disciplinarity as idiosyncratic, innovative, and always already exceptional.

What Does it Mean to Be an Engineer?

Speaking from personal experience, situating oneself at a large, research-oriented university with a strong engineering program is one of the best ways for an “outsider”\(^\text{10}\) to explore the activities of engineers. Here at this university, where alumni, private companies, and the U.S. government send millions of dollars to support research, the whole campus is implicated in the enculturation and knowledge production of engineers, including (and perhaps especially) teachers of English. In similar fashion, Dorothy Winsor’s tenure at Kettering University, where she became responsible for teaching what it means to “write like an engineer,” transformed her from a professor of Communications—theoretically an outsider to engineering—into an integral component of the enculturation of engineers. This shift in Winsor’s positionality led to her innovative research (1996) on the communicative competencies of engineers and refutation of widely-held beliefs about how engineers learn to communicate.

Though engineers are often classified by non-engineers as inarticulate, illiterate, and incapable of interpersonal interaction, Winsor (1996) finds that her participants—four engineers-in-training—are often just as eager to disparage their own writing abilities. She writes,

\(^{10}\) Assuming that most readers of this text are not engineers, we will confront the anxiety Lewontin aptly describes in the opening paragraphs of “Fact and the Factitious,” struggling with our expectations that as “novices” to the texts and discourses of engineering, we have no choice but to be ignorant and alien. Such expectations are understandable, but we must not forget that they are predicated on models of disciplinarity that we have already begun to question!
Folk wisdom has it that engineers are bad writers. This is, I think, a belief that deserves some consideration. What does it mean to write badly or well as an engineer? Why should a group of intelligent, educated people write less well than, say, biologists? (p. 4)

In her research, Winsor (1989; 2003; 2004) isolates numerous examples demonstrating that engineers are constantly communicating, often with great success. Winsor’s work challenges us to see engineering texts as legitimate writing and to recognize that engineers are constantly writing. Likewise, Bazerman’s (1988) research on scientific genres, Connors’ (1982) history of technical writing instruction in the U.S., and Russell’s (1991) studies of disciplined writing in academic settings have done much to normalize technical communication for scholars with non-technical backgrounds (see also Herrington, 1985; Berkenkotter & Huckin, 1994). This process of demystification of “insiders” by “outsider” research is also observable in the philosophy and history of science (Latour, 1987; Lynch & Woolgar, 1990) and in engineering education (e.g. Florman, 1996; Barley & Orr, 1997; Margolis & Fisher, 2002). Even texts written primarily for engineers and engineers-in-training often shed light on composition in engineering: Tufte’s (1983; 2003) work in information design, Alley’s (1989; 2000) instructional materials for writers in science and engineering.

Like Winsor, I have been surprised at just how powerfully my data complicate the prevailing understandings of theorists of disciplinarity (Snow, 1959; Biglan, 1973; Swales, 1990; Becher & Trowler, 2001) and of my participants themselves. All of my participants were writing daily in multiple contexts, often with great success. Yet, in interviews, nearly everyone invoked a belief that engineers “can not write” or “do not write.” Given that their statements demonstrated a clear inconsistency with their practices, I asked participants how they could
account for the discrepancy. In response, many participants reasoned that if they were competent and frequent communicators, it was because they must not be representative of most engineers.

I have been struck by how few of my participants regarded themselves as representative of the average engineering student, teacher, administrator, or staffer. Only three were willing to call themselves “real” engineers. When I asked, “What does it mean to be an engineer, and how does one become an engineer,” participants frequently protested, insisting that I instead call them “students,” “scientists,” “research scientists,” “interns,” “chemists,” “coders,” “mathematicians,” “philosophers,” or “teachers.” The lack of a shared sense of what it means to be an engineer, and my participants’ routine practices of disassociation from their discipline disrupted the ways in which I understood disciplinarity. Moreover, no one seemed to agree on what the core canon of engineering might be; the artifacts graciously and patiently shared with me (homeworks, data sets, group projects, lesson plans, syllabi, learning outcomes, and lab reports) have very rarely coalesced to indicate what engineering’s “insider information” might be.

Leslie and Michael

Leslie, the Assistant Director of the Academy for Excellence in Engineering Education at UIUC, is, like Lewontin, someone we might consider exceptionally disciplined. Leslie initiated her career in the College of Engineering as an import from her graduate program in literary studies, from which she received her doctorate in 2000. Several years into her dissertation on the medical literatures of childbirth and motherhood, during which time she taught undergraduate courses in professional writing, she came upon a unique opportunity to TA for a senior design course in the mechanical engineering department:
The engineering students had to do some kind of project and produce written documents with it throughout the semester. My boss in the professional writing program had asked a lot of people and no one else wanted to do it, so I thought, “that sounds kind of cool and fun.” So I taught mechanical engineers how to write project proposals and senior design projects, and I had to learn really fast how to do that. All of a sudden, I was reading things about refrigerator coils. These days, Leslie manages to maintain an identity as a reader, writer, and poet as well as an administrator in the College of Engineering. Several years ago, she even founded her own company, which offers therapeutic writing, workshops, and editing services. She also maintains a blog, a space she uses to help make sense of these multiple roles.

As Leslie recounted her circuitous path to her current job and extracurricular activities, I noticed how much her language marked her as an insider in the field of engineering. Not only did she discuss technical things like refrigerator coils with confidence and ease, she explicitly addressed her experience of shifting disciplinary allegiance, which went far beyond a merely strategic career move:

I really liked the students, and this is still what I love about engineering, is that it’s so involved in the real world. So, just the energy of it, compared to the energy of the English department, where people would be skulking around the halls, never thinking they’d finish their dissertations or get a job. This was a whole different world, and I absolutely loved it.

But at the time, Leslie was not always welcomed as an insider, particularly by her new boss, the long-term instructor of the design course she was learning to teach:
They had this curmudgeonly guy who had been teaching it for years and years, but he was about to retire so they needed a TA to teach it. He was not particularly well liked by the department, and he was prejudiced against the English department. He would say to me, “So are you going to hang up macramé in your new office, or what?” But I liked him because he was a really good teacher.

Leslie’s tolerance of her new mentor’s petulance speaks a lot to her ability to lead a successful life despite (or owing to) her multidisciplinarity. She also has a knack for capitalizing on the transferability of her skills across literary studies, creative writing, entrepreneurship, education, and engineering, and there are many significant crossovers between Leslie’s primary career as an engineering administrator and her other activities. For instance, at work, she is particularly interested in student engagement and supporting students who are on probation, which she sees as two sides of the same coin. Her goal is to help students to sustain the energy that originally attracted her to the discipline of engineering fifteen years ago. These efforts to be a sustainer of energy have bled into the other parts of Leslie’s life, especially into her more recent work in the field of therapeutic writing.

Conversely, the entrepreneurial skills that facilitated Leslie’s founding and management of a therapeutic writing company echo key professional activities she has developed during her work in the College of Engineering:

I work with a guy named Michael Alley who’s written a couple books on writing for science and engineering. We’ve worked together for about ten years. It started this one day when I was sitting in my horrible office in the mechanical engineering building, and I found one of his books, and I thought, “I wonder if I could invite this guy to come and talk to our students?” So I just called him and
told him, “I’m TA for this mechanical engineering class, would you be interested in coming here?” And he was like, “I would love to do that! My wife graduated from mechanical engineering!”

And although Alley “has become phenomenally well-known,” since Leslie’s first interaction with him, her social strengths have helped the working relationship withstand the tests of time and fame.

For both technical and non-technical readers and writers, Alley’s work is a particularly helpful way to understand writing genres in science and engineering from the rhetorical and grammatical perspectives with which writing researchers are most familiar. Alley’s extensive writings have recently grown to include analysis of oral presentations and the re-design of presentation slides. Much of Alley’s work is available for free through his website, and he frequently writes as though addressing an engineering novice or even an anthropologist, as in the first chapter of *The Craft of Scientific Writing* (1993):

If you ask a scientist to advise you about writing, you’re likely to get a quick list of rules [such as] “Be objective. Use synonyms for variety. Begin each paragraph with a thesis statement.” These rules come from freshman composition classes taken years ago; late night conversations with thesis professors; DOs and DON’Ts articles cut out of company newsletters. However, when it comes time for you to actually sit down and write a scientific paper, these rules don’t help much. What makes these rules easy to remember also makes them valueless; they’re too simple and general. (pp. 8-9)

Such frank discussions of the ways in which engineering texts are and are not produced problematize the insider/outsider dichotomy, the weaknesses of which are not lost on Alley, who
introduces his first chapter with a quote from Ernest Hemingway: “We are all apprentices in a craft where no one ever becomes a master” (as qtd in Alley, 1993, p. 3).

Alley’s texts are some of the most well-loved and widely read in college-level science courses. All but one of the professors I interviewed had an Alley textbook somewhere in his or her office, and nearly all included mention of an Alley text somewhere on his or her syllabus. He is seemingly everywhere present in the enculturation of engineers at UIUC, and not, as Leslie explained to me, only though his writings:

He’s been here several times to do presentations and workshops for graduate students, and they always are completely full. Usually we try to cap it at 75, but sometimes it goes up to 100 students, because professors who are advising these students are like “please take these people and teach them how to communicate.”

For some scholars, the practice of outsourcing rhetorical education to English TAs (e.g. Leslie), faculty in departments like Communications (e.g. Winsor), or specialists (like Alley) suggests something disturbing about the division of labor in the academy.

Bazerman et al. (2005) raise concerns about the extent to which writing instruction and subject matters have been divorced. My project asks that we consider the impact of such outsourcing practices on our models of disciplinarity: Not everyone involved in the enculturation of engineers is herself an engineer. Moreover, as we will see in this and the following chapter, not all engineering students are novices and not all engineering faculty are experts. The story of Leslie and Michael illustrates just how impoverished a model of disciplinarity is when it is predicated on a belief that people fall cleanly into obvious categories like “novice” or “expert.” In the next section of this chapter, we will examine the texts and talk about texts of engineering students, and as we do so, we will see just how disruptive these texts are of pat notions of
An Expert Novice

In Fall 2009, when I asked Andy, then an eighteen-year old freshman in the computer science program, if he considered himself an engineer, he chuckled. It was a complicated question, he told me, but the short answer was “no.” In fact, he admitted that a recent job experience at an engineering company had shifted his sense of what he wanted to do with his life; “I enjoy computer science, enjoy programming, but since my summer internship at Motorola, I’m not really sure that computer science as a career is interesting to me.” From his explanation of his role at the company during the summer internship, it was clear that Andy was already succeeding as an engineer:

At Motorola I was working with a group of five or six people who were integrating the software for the Razr II cellphones. There were a whole bunch of groups that worked on individual components like the media player, email, and our job was to make sure they all built together into a coherent image that could be put onto the phone. Specifically, I was working on making it build faster. When I came in, it was taking about a day and a half to build the software, and by the time I left, it took half an hour to an hour.

It seemed significant that Andy was disassociating himself from engineering not because of a failure to thrive at Motorola or dislike of the collaborative programming process, but because of his lack of interest in the corporate culture. Yet his resistance to identifying himself as an engineer also had much to do with his forays into other disciplines, particularly his readings into secondary education. Though he had already begun to consider a career as a math and computer
science teacher in earnest, Andy was resolved to complete his degree program in the College of Engineering.

When I asked Andy about what he liked to do in his spare time, he told me about an online graphing calculator program he had written, and I felt him shift from disassociation to association. Figure 2.1 below displays the index page of the website Andy created to host his calculator program, a complex combination of alphanumerical and alphabetic texts that is clearly only the interface of a much more structurally complex algorithm.

![GraphSketch.com](image)

*Figure 2.1: GraphSketch.com allows visitors to create graphs of complex functions.*

Based on the texts Andy has produced, it is hard to deny that he commands a level of knowledge and ability we do not normally associate with students, let alone students in their first year of college. And if it were possible to capture the discipline of engineering by indexing a body of “essential information,” to use Lewontin’s phrase, that information would be calculus, which
Andy has more than mastered. Calculus was, in fact, invented—first by Leibniz, in 1684, and later by Newton, in 1693—to enable us to explain the laws of physics. By plotting trigonometric functions, Andy’s website essentially translates between calculus and physics, allowing for the visualization of limits, derivatives, integrals. Such visualizations are crucial in engineering to calculate for unknown lengths, areas, and acceleration in complex situations, and engineers regularly make use of calculators like Andy’s in order to make decisions about materials, weights, distances, heat capacities, computer programs, and corrosion thresholds.

With programming activities that associate him with the professional practices of engineers as well as the enculturation of engineering students, Andy has insinuated himself into the discipline.

---

**About:**

Beyond simple math and grouping (like \((x+2)(x-4)\)), there are some functions you can use as well. Look below to see them all. They are mostly standard functions written as you might expect. You can also use \(\pi\) and \(e^x\) as their respective constants.

**Please note:** You should not use fractional exponents. For example, don’t type \(\sqrt[3]{x}\) to compute the cube root of \(x\). Instead, use \(\text{root}(x,3)\).

When you want a quick graph of a function, you can just go to http://graphsketch.com/(function), like http://graphsketch.com/sin(x). You can even separate multiple equations with commas, like http://graphsketch.com/sin(x),x^2.

For more information on GraphSketch (how it works, etc.), see my blog post on it.

**Support GraphSketch:**

GraphSketch is provided by Andy Schmitz as a free service. Buying a poster from posters.lardbucket.org helps support GraphSketch and gets you a neat, high-quality, mathematically-generated poster. If you’re interested, take a look. Thanks!

**Functions:**

<table>
<thead>
<tr>
<th>To get</th>
<th>(\sin(x))</th>
<th>(\cos(x))</th>
<th>(\tan(x))</th>
<th>(\sin^{-1}(x))</th>
<th>(\cos^{-1}(x))</th>
<th>(\tan^{-1}(x))</th>
<th>(\pi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>(\sin(x))</td>
<td>(\cos(x))</td>
<td>(\tan(x))</td>
<td>(\sin^{-1}(x))</td>
<td>(\cos^{-1}(x))</td>
<td>(\tan^{-1}(x))</td>
<td>(\pi)</td>
</tr>
<tr>
<td>To get</td>
<td>(a^b)</td>
<td>(\sqrt{x})</td>
<td>(\sqrt[3]{x})</td>
<td>(\log(x))</td>
<td>(\ln(x))</td>
<td>(e^x)</td>
<td>(e)</td>
</tr>
<tr>
<td>Type</td>
<td>(a^b)</td>
<td>(\sqrt{x})</td>
<td>(\sqrt[3]{x})</td>
<td>(\log(x))</td>
<td>(\ln(x))</td>
<td>(\exp(x))</td>
<td>(e)</td>
</tr>
</tbody>
</table>

**Figure 2.2:** Andy made GraphSketch.com before he entered the engineering program at UIUC.

“As of this afternoon,” he told me with pride, “it has served 28900+ graphs to somewhere around 8400 visitors,” many of whom, he explained, were probably high school teachers and students in math and science courses. The pride he feels has more to do, it seems, with his ability to use his programming skills to reach out to students and instructors in secondary education, and Andy, it
turns out, has invented many such algorithms for the benefit of middle and high school students: a schedule-sharing website that allows students to see what classes their friends have signed up for, the homepage for the high school LEGO league, the member page for a local robotics competition. If Andy’s practices of association and disassociation with engineering have not resulted in a well-defined disciplinary identity, they have without question allowed Andy to balance his knack for programming with his fascination with secondary education, cognition, and mathematics. And, as with Lewontin, Leslie, and Michael, it is equally clear that the words “novice,” “expert,” “insider,” and “outsider” fail to capture the nuances of Andy’s knowledge production practices.

**Essential Information?**

Andy does consider himself an exception to the “average” computer science student, and justifiedly so, since he has such a unique set of interests and isn’t interested in pursuing a career as a “traditional” engineer. But even the “traditional” engineers with whom I have spoken sometimes violate basic understandings of what counts as the canonic or essential information of engineering, as in the case of Rob. Now an associate at a business and technology consulting firm and the owner of a new start-up internet company, Rob is well on his way to becoming what he calls “the entrepreneurial engineer.” His professional resume, which is posted publicly on a social networking site, explains that his specialties coincide with the most in-demand technical skills of today: database management, website design and development, server setup, programming, and image editing. But elsewhere on the same page, Rob also uses the words “writing, management skills, and marketing” to describe his interests, which complicates a strict disciplinary reading of his competencies.
I first spoke with Rob in 2009 when he was a senior in computer science, and I was immediately struck by his free and easy ability to converse with a total stranger. When I noted his poise and sociability, he explained that he did not see these characteristics as distinct from the project of becoming an engineer. Although he was well aware of the stereotype of the “lonely, pale computer programmer,” he insisted that skills like writing, oral communication, and networking were not only crucial, but indigenous to his field. Computer science students, Rob explained, are required to write articulately and grammatically all the time, though people with limited technical training might not recognize some of their writing as such. For example, an excerpt from one of Rob’s computer science homework assignments (Figure 2.3) consists of a series of logically and syntactically perfect phrases, though some understanding of the technical lexis is a prerequisite to being able to identify the text as a series of logical, complete thoughts.

**Figure 2.3**: An excerpt from Rob’s computer science homework from Prof. Lawrence’s class.
The English-language translation of the text in Figure 2.3 might be something like:

Certain arrangements of openings and closings in an electrical circuit can communicate logical functions. In combination, one type of arrangement—called a “NOR gate”—can generate any other logical function.

By comparison, the next text (Figure 2.4) is somewhat less opaque to unspecialized readers, particularly because the technical lexis is integrated with more broadly used forms of alphabetic and alphanumeric text. The graph comes from a market analysis and strategy report for a new picture-taking technology—called geotagging—which allows the photographer to capture not only an image, but also the coordinates of the location, date, time, and shutter speed of the shot.

Below, the dark grey vertical bars represent the costs (in USD) of various products on the market. A snapshot of the gTag brand card, the fictional product for which this report was written, has been Photoshopped into the graph to emphasize the relative inexpensiveness of the gTag Card (i.e. the short height of its grey price column).

*Figure 2.4: An excerpt from another of Rob’s assignments.*
Moreover, unlike the computer science text in Figure 2.3, the graph in Figure 2.4 contains redundant information: the caption within the text, which explains the “Prices of Competitors” graph, reads, “The gTagCard targets the lower price range of the market and will compete with existing GPS solutions that require more time commitment for geotagging.” This additional, redundant information is not an error. Rob rendered the graph in this way to make it more accessible to a wider audience.

But if it was made to be accessible to both technical and non-technical readers, is Figure 2.4 an engineering text, an economics text, or something else? Examples like the one pictured in Figure 2.4 document the ambiguous disciplinarity of the large majority of texts produced on a day-to-day basis. Aside from our knowledge that both Figures 2.3 and 2.4 were produced by Rob in the course of his education as an engineer, what information do we have to recommend them as part of the “essential information” of engineering? One could argue that, as it pertains to the development of new applications of GPS technology, the graph in Figure 2.4 is just as disciplinary as the symbols pictured in Figure 2.3 (enlarged version shown below in Figure 2.5).

![Figure 2.5: Building blocks of Boolean logic from Rob’s computer science homework](image)

Boolean logic, which is the principle captured in Figures 2.3 and 2.5, was a necessary precursor to innovations like digital electronic circuit design, search engines, and databases, and represents the kind processing power that has made recent advancements like GPS and geotagging (as...
represented in Figure 2.4) possible. One might argue that both texts were produced by an engineer, and thus both are necessarily engineering texts, as we are all likely to infuse our educations, histories, and values into the texts, often without recognizing it. On the other hand, we might argue that these texts were produced not by a “real” engineer, but by a student/novice, and thus are not necessarily “essential information.” This argument is less compelling given our introduction to Andy in the previous section, the freshman computer science student who has already contributed substantially to the cell phone technology currently on the market. However, it would also be possible to argue that Figures 2.3 and 2.5 concern essential texts of engineering because they were produced in an engineering class, and Figure 2.4 is fundamentally not an engineering text because Rob produced it for his marketing class taken through the College of Business. Yet all of these arguments are circumstantial, which suggests that there are very few meaningful generalizations to be made about canonicity outside of everyday activity.

A Professional Student

Issues of professional communication were also in the foreground of my conversation with Sherri, although her thoughts were much informed by her status as a non-traditional student:

I’m a student in ECE [Electrical and Computer Engineering] 316, and I’m also a manager for a software engineering and analytical consulting firm. We work primarily in the area of facilities management, and we also have an engineering division and a road pavement division. We’re a small company; we have about thirteen employees and about twenty to thirty sub-contractors that we use off and on for various things. So I [have] a perspective as both an employer and a student.
Now in her forties and returning to school after many years, Sherri’s experience with professional engineering and professional communication is significantly larger that most of her classmates. She became more and more confident as she talked about her job, and I was struck by her concern for new and prospective employees in the engineering division.

As an employer, one of the main things that management says is they can’t talk to the engineers. Software engineers, building engineers, HVACs, electrical…it’s like they speak a whole different world. So communication with them is always difficult. It always causes frustration in the workplace. You notice it when you’re trying to hire people, in their resumes, even in their interviews.

This problem with cross-disciplinary communication is a big part of the reason that Sherri decided to come back to school. To be sure, she is interested in more efficient and effective communication with the engineers she is interviewing and employing, but she’s also interested in forging better relationships with her customers; one of her company’s biggest clients is the Army Corps of Engineers.

I think a lot of that is that engineers tend to talk their language…instead of what the manager is used to talking in. They’ll talk in acronyms, make assumptions that managers know everything they know as an engineer. Managers assume that the engineers already have the skills to take what they know and transform that into language the manager can understand.

Although Sherri described a lack of mutual curiosity between disciplinary divisions at work, she herself was very interested in cross-departmental communication, and said that all students at UIUC should have to take an engineering class so that they can appreciate the infrastructure.
When Sherri and I transitioned from our discussion of her management role at work to her current life as a returning student, there was a noticeable shift in her tone and demeanor; she became less assertive, more self-deprecatory and even a little defensive. She admitted that she often feels she alone is struggling to keep up with all course texts:

To participate in this class, you really need to WANT to. The other day, just out of curiosity, I stacked the books up, to see how tall they were, and it’s up to my hip! That’s a LOT of reading material just for one class. And I’m an older student, really trying to get the most out of it that I possibly can, and I have a lot of family and work responsibilities and, you know, discouragements.

But Sherri clarified that her struggle to keep up was due not to her relative inability to perform as a student, but to her perception of exigency compared to her classmates. She engages with course texts differently from her less experienced peers. By way of explanation, Sherri compared her own reading practices to the ones she observes in students who sit nearby:

When I’m studying, I’m really focused on it, wanting to learn. But there’s no way some of these students read all their assignments, I mean, the girl that sits next to me, I can tell from the pages upon pages with no highlighting [in her books], no notes written on the sides, you know. Every one of my books are just COVERED with little notes to myself and highlighting. So you can tell certain students didn’t do that, you can tell by the students who participate in class.

It was clear from the start that Sherri was an exceptionally disciplined student; what wasn’t clear was the nature of this exceptionality. But when I asked Sherri what kind of student she had been when she first went to college, I began to understand that what makes her different is due not only to age, career, and life experience, but also to issues of class:
When I first went to school, for Business Administration, I went to one of the area community colleges. I always say that I got a better quality education from the junior college, but I’m getting a better quantitative education from the university. Which isn’t to belittle either one of them, it’s just the type of atmosphere.

Sherri’s notion of “atmosphere” indexes key institutional and acculturative forces at UIUC, which I will explore more fully in Chapter 5. But her words also point to something so obvious and important that models of disciplinarity omit—discipline is constrained by socioeconomic forces, as well. Engineering at a small-town community college is not the same discipline as engineering at a research university. This is not, as Sherri says, to denigrate either; it’s just the type of atmosphere. And as Sherri put it, “They know in small-town colleges that students can’t afford books that are coming up to your hips.”

**Genre Hacking**

Everyday writing in engineering includes the making of many kinds of texts, from lab reports to PowerPoint presentations to essays, cover letters, and resumes. These texts are recognizable by their integration of technical lexis and layspeak, as in Kevin’s PowerPoint presentation on “Smart Skin” (sample slide in Figure 2.6). Kevin, a graduate student in electrical and computer engineering, explained to me that his objective was to explain both some of the foundational knowledge required in producing “Smart Skin” as well as some of the applications of the technology. Accordingly, he combined lay words (“Smart Skin”), technical lexis (“Flexible substrates,” “MEMs,” “Large-area Microfabrication”), and a series of non-technical images.
The three grainy pictures at the bottom of the slide (Kevin apologized for their poor quality) are meant to help the audience understand the tangible results and potentialities of Smart Skin: robotic touch, airplanes, and dynamic temperature-controlled clothing. We also see Kevin’s deliberate use of redundancy, as the contents of the boxed lists on the right and left sides are reiterated and spatialized in the central diagram of the slide. In sum, Kevin’s collage makes an argument for the validity and importance of his research—an argument meant to be understood by a variety of audience members.

The PowerPoint genre is particularly tolerant of this collage approach, and perhaps for this reason, has been adopted by many engineers (e.g. Michael Alley) as a primary form of communication. And yet, as Alley (2004) explains, the rigidity of the default structure of PowerPoint is something that writers like Kevin must overcome in order to make strong arguments.

Recently, much criticism has arisen about the common practice use of Microsoft PowerPoint. This web page challenges PowerPoint's default structure of a single
word or short phrase headline supported by a bullet list. Rather than subscribing to Microsoft's topic-subtopic design for slides, this web page advocates an assertion-evidence structure,...which serves presentations that have the purpose of informing and persuading audiences about technical content. (Rethinking the Design of Presentation Slides, para. 1)

This argumentative structure, which Alley calls the “assertion-evidence structure,” is a featured technique in his discussions not only of PowerPoint presentations, but also of many other kinds of technical writing (see Rowley-Jolivet, 2002).

The same rhetorical structure emerges in the following essay by Jordan,\textsuperscript{11} an undergraduate student and prominent event organizer on campus. When read as an image, Jordan’s essay on search engines (Figure 2.7 below) may not look like an engineering text. Although it is arranged into six-to-ten-line paragraphs, we can see that Jordan is following something like the assertion-evidence framework from Alley’s advice on PowerPoint. The text begins with an assertion about the similar results of queries to three different internet search engines. Jordan follows up his assertion with the supporting evidence that all three engines list the same few hits first. For balance, he moves on to consider the differences among the three engines, providing examples of those variations and possible explanations.

Because he is concerned with supplying interpretations as well as evidence, Jordan’s piece is also reminiscent of another technical genre, the “Results and Discussion” section of a lab report. Jordan’s interpretations are based in specialized knowledge of the principles of engineering that come to bear on the results, but he deploys his engineering knowledge differently because of the class context. Jordan’s paper is for a class called Informatics 202,

\textsuperscript{11} Not his real name.
which is taught through a collaboration of social science departments and purports to explore “the way in which information technologies have and are transforming society and how these affect a range of social, political and economic issues from the individual to societal levels.”

Figure 2.7: Jordan’s text exhibits formal features of several different genres learned in school.

When Jordan draws on his understanding of the weaknesses of certain web-based programming platforms, he signals his outsider-ness; by indexing expertise that his reader is not likely to have,
he flaunts his relative authority in a situation where he is otherwise less expert than his humanist classmates. However, he also translates the specialized discourse in a way that will enable comprehension, inviting the reader “inside” engineering, albeit temporarily.

At the time Jordan wrote this essay, he had also recently taken a first-year writing course through the English department. It is interesting to see how few features his paper shares with the kinds of writing practices often taught in such classes. For instance, the practice of using an introductory paragraph first to “hook” the reader and then to introduce a thesis statement is noticeably absent from the first page of Jordan’s paper. Jordan explained that his paper’s structure seemed more relevant to his own thought process: “I think we [engineers] often use the scientific method, even if we don’t recognize it. Developing a hypothesis, testing, repeating. That’s what engineers do on a daily basis.” And yet Jordan’s piece is also conspicuously not a lab report, as it lacks many of the sections that are routine in that genre: abstract, introduction, hypothesis, and methods. Instead Jordan has blended formal features of humanities essays and lab reports, and in so doing produced a hybrid genre.

When I asked Jordan to talk about writing as an engineer, he said, “a lot of people say that writing code is a very creative process. It’s not so much of a science as it is creativity.” He then brought up the notion of hacking to help explain,

“Hacker” has a negative connotation amongst the wider United States, but in the computer science world, hacker just means someone who tries to take something and improve upon it, make it better or make it work in a way that it’s not necessarily used for. And a lot of us would consider ourselves hackers. Jordan’s words shed some light on his rhetorical approach to his Informatics 202 paper. Without a precedent to follow, Jordan would have had to fumble to find a format that would achieve the
goals of his prompt, and rather than mechanically adopting a genre that did not feel entirely comfortable (e.g. from first-year composition), he resorted to hacking (i.e. modifying and extending) the lab report genre.

Most school environments encourage some “genre hacking” for educational purposes, licensing teachers and students to adopt genres from extracurricular contexts and adapt them for use as educational tools. Seminar papers approximate journal articles, scaffolding students toward disciplinary models before they are ready to publish. Course syllabi take on the conventions of legal contracts, where policies and language can both direct student behavior and arbitrate penalties should misbehavior occur. The reference to a university’s plagiarism statement in a course syllabus, which lends syllabi the authority of a legal document, is a perfectly reasonable generic appropriation, one for which we are all likely “guilty”. Even Lewontin’s (1991) essay in *Critical Inquiry*, which opened this chapter, is a playful act of genre hacking, reminiscent of earlier attempts (e.g. with Gould, 1979) to “retrofit,” as Couture (1993) suggests, “scientific knowledge about evolution by manipulating the structures of written language” (p. 276). Genre hacking, thus, recalls Leont’ev’s (1981) model of enculturation, wherein appropriation is a key mechanism of learning, both more sophisticated and more instrumental than mere borrowing or plagiarism.

While writers like Michael Alley provide a plethora of guidelines and examples for genres like lab reports, PowerPoint presentations, proposals, and progress reports, there is very little advice for engineering students to write five-page comparative essays. However, Alley’s body of work does provide significant advice on many genres not normally associated with writing in science and engineering. For instance, Alley dedicates an entire subsection of his science writing web page to “Correspondance,” including several templates and samples.
Ironically, though Alley frequently cautions his reader that genres like lab reports are extremely variable and dependent on context, he gives extremely precise, rigid guidelines for writing professional correspondence. To his thinking, business letters must be single-spaced and typed in serif font, and writers must use no more than seven lines per paragraph, no more than twenty words per sentence, and plenty of negative space.

Sample Letter Format

Company Name
Company Address
Date of Letter

Recipient's name
Recipient's title
Recipient's company
Recipient's company address

Recipient's Name:

People read business letters quickly. Therefore, get to the point in the first paragraph--the first sentence, if possible. In other words, state what you want up front.

Single space your letters and use a serif typeface. Skip a line between paragraphs. Because people read business letters quickly, use shorter sentences and paragraphs than you would in a longer document. Sentences should average fewer than twenty words, and paragraphs should average fewer than seven lines.

Space your letter on the page so that it does not crowd the top. However, if possible, keep your letter to one page. Second pages often are not read. Send copies to anyone whose name you mention in the letter or who would be directly affected by the letter.

Final paragraphs should tell readers what you want them to do or what you will do for them.

Sincerely,

Signature

Name

Figure 2.8: A humorously meta-generic sample letter from Alley’s website.
Through the lens of Miller’s (1984; 1994) notion of genre as social action, we can understand Alley’s unequal estimation of exigencies in these writing situations. As Miller writes, “exigence is a form of social knowledge – a mutual construing of objects, events, interests, and purposes that not only link them but make them what they are: an objectified social need” (p. 30). Thus, Alley sees technical genres (i.e. those more native to his professional activities as a scientist and teacher) as more complex than he does more remotely exigent genres like “Correspondance.”

However, in engineering, business letters are frequently more socially exigent than lab reports, particularly in the case of students applying for summer internships, externships, and post-academic jobs. When Gina, a senior in agricultural engineering, spoke with me about her professional writing class, which she took last year through the English department, she explained that many of the documents she turned in were modified from ones she had prepared during her rigorous search for an engineering internship the year before. For instance, the mock cover letter she submitted to her professional writing teacher was based on one she had used to obtain a summer job at John Deere.

Gina’s letter (Figure 2.9 below) violates nearly every single one of Alley’s guidelines: her sentences have an average of twenty-four words each (several sentences have more than forty words!), her paragraphs are much longer than advised, and the text has indeed been crowded in order to fit the letter into one page. Yet we should be inclined to think of her letter as an example of good engineering writing rather than bad because it was successful in catching and holding the attention of the human resources department at a premiere engineering company. Moreover, Gina has followed the spirit if not the letter of Alley’s advice. Because she uses the assertion-evidence framework to make scientific arguments for her employment, we might think
of her letter, like Jordan’s comparative essay, in terms of genre hacking: it is a hybrid of professional writing and engineering writing conventions.

Figure 2.9: Cover letter recognizable as a professional writing, but also as an engineering text.

The letter begins by both explicitly and implicitly indexing her discipline, all the time working against the stereotype, she explained to me, of the shy and socially inept engineer. She
both espouses her engineering training (“I will be graduating in May 2010 with a Bachelor of Science in Agricultural and Biological Engineering…”) and articulates herself as well-rounded, communicative, and adaptable by associating herself with other practices (“accountancy, finance, marketing, and business,” “fluent in Spanish,” “Alpha Omega Epsilon,” etc.). And yet, throughout her avowal of these seemingly non-disciplinary activities, she also presents an engineer’s understanding of systems and applications of abstract information (“a skill that will lend itself well to…” and “a skill that will be useful when…”). In so doing, Gina deftly walks the line between under-qualified and over-disciplined.

Not only is genre hacking a distinguishing characteristic of Gina, Kevin, and Jordan’s disciplinary practice, there is much evidence (as we will discover in the following chapter) to suggest that playful acts of appropriation—understood in terms of Leont’ev’s (1981a; 1981b) models of appropriation and self-assertive motives—are a key feature of acculturative practice in engineering.

**Exceptionally Disciplined**

Textual artifacts and our ideas about texts both succeed and fail to capture the practice of discipline. In using disciplinary texts to understand what makes someone a novice or an expert, we ultimately raise more questions than we answer. As we have seen from the student perspective, engineering is more than just a corpus of texts, and enculturation into a university is comprised of many disparate experiences: classroom interactions and collaborations, cultural activities, idiosyncratic histories, field-specific activities, and everyday literate practices. We’ve seen how complex literate lives of individuals intersect in generalized curricula (Leslie and Michael), and different people negotiate similar geometries, sometimes with common results, but
often with very different outcomes (Andy and Rob). Though students are socialized to follow certain disciplinary guidelines and embrace new values, individuals remain individual, and their messy idiosyncracies remain messy and idiosyncratic.

People negotiate these trajectories in creative ways: a dance of strategic association and disassociation with and from disciplinarity. Leslie, who should by all accounts be an outsider, associates to recover her energy and the energies of young engineering students. Gina both associates and disassociates to win a competitive internship. Sherri associates to reinforce her career, but disassociates to articulate her class struggle. In some cases, being an exception is a choice—a strategic way to get a job (Rob), an internship (Gina), or a promotion (Sherri), a way to finance one’s passion for secondary education (Andy). But exceptional disciplinarity is also not a choice—it manifests indirectly through the other choices we make, in the work one produces (Jordan and Kevin), and in demeanor (Alley). The texts in this chapter are “core engineering texts” because they came from engineering students, but they’re also not engineering texts. The next chapter will explore whether we would we get the same impression if we considered the textual products of “real” engineers or of engineering faculty,

Accordingly, it seems we should be asking not “what does it mean to be an engineer?” but “how do teachers and researchers associate and disassociate themselves from engineering, and why?” In other words, to understand what it means to be an engineer, we must follow Latour’s (2005) ANT roadmap for the tracing of associations, starting with controversies, moving to associations, and then to “reassembling the social.” Rather than struggling to isolate the parameters of disciplinarity, the following chapter will continue to pursue what it means to be controversial, to be an exception to a disciplinary rule. With this as my lens, I will work to discover hidden associations, revealing how texts, practices, and people routinely travel within,
across, and beyond abstract notions of disciplinary boundaries, so often as to render such boundaries questionable, at best. Questioning such bounded notions of disciplinarity and calling attention to the routine ways in which supposed boundaries are crossed, ignored, and rewritten does not, however, suggest that disciplinary actors are not constrained and restricted by boundaries of various types. In other words, representations of disciplinarity can discipline and exclude people, even as disciplinarity itself appears fuzzy and emergent.

The following chapter explores these questions by considering the ways in which faculty play and facilitate the “game” of enculturation. Do teachers and researchers portray a more straightforward disciplinarity? Or are they, too, exceptionally disciplined? Do they also engage in “genre hacking?” And, if teachers and researchers are also playing with discipline, how do they expect their students to react to their playfulness? How might these kinds of games become vital components of the enculturation process?
Chapter Three: Enculturation Games

“You take the easy way out! You talk about all sorts of language-games, but have nowhere said what a language-game is.” And this is true. These phenomena have no one thing in common which makes us use the same word for all. Consider the proceedings that we call “games.” You will not see something that is common to all, but similarities, relationships... I can think of no better expression than “family resemblances.” And I shall say: “games” form a family.

Ludwig Wittgenstein

Wittgenstein (1953) saw language in terms of “family resemblances,” the term he used to explain the group-ability of texts by their similarities. His comparison of language-use to game-play, through his phrase “language games,” captures much of what is fascinating about both: they are enjoyable, negotiable, discursive, and bound by tangible rules that are nonetheless very hard to pin down.

In her book Writing Games, Casanave (2002) extends the game metaphor to multicultural, multilingual case studies of enculturation at multiple levels of higher education, borrowing from Ortiz and Bourdieu as well as Wittgenstein. Here, I extend Wittgenstein’s analogy a step further, presenting what I am calling “enculturation games” as an alternative, superior model for understanding how engineering students, staff, and faculty acculturate and how disciplines shift and permute over time. By blending Wittgenstein’s notion of language games with Casanave’s feminist take on game-play, I reconsider the discipline of engineering

from the perspective of its more and less visible mechanisms of enculturation in search of family resemblances. Ultimately, I argue that the game-play metaphor is both more evocative of disciplinary enculturation than are other models (discourse communities, cultures, tribes, territories, communities of practice) and more reflective of engineers’ own conceptions about their disciplinary learning and communication practices.

**Enculturation as Game-Play**

Aside from Casanave, enculturation is rarely represented as playful in the research on disciplinarity and writing. Becher’s (1989, 1999) and Swales’ (1990, 2004) popular models represent disciplinarity hierarchically, in terms of more or less rigid norms that must be learned and reproduced in order to attain legitimate membership. In *Tribes and Territories*, Becher (1989) casts disciplinarity as a top-down phenomenon rather than the aggregate of individual practices; he begins with market forces, moving to institutional management strategies, and then to departmental practices, but nowhere considers how learning and identity-formation happen at the individual level. While Becher later acknowledges that the participants in his (1999) study of professional practices “seemed inclined to play down the value of formal course provision in comparison with the learning undertaken on their own initiative as part of the natural ebb and flow of their professional lives,” he positions these informal acculturative practices as secondary to more formal professional development activities (pp. 173, 205). Likewise, Swales’ (2004) study of research genres presents enculturation into discourse communities as a movement from writing less influential genres, like review articles, to more prestigious ones such as monographs and keynote lectures. And though his (1990) representation has been problematized by Prior
(1998) for being too antiseptic to bring much clarity to the contextual and heterogeneous nuances of social practices, research following Swales’ conservative notion of enculturation has endured.

By introducing the element of play, Casanave’s (2002) ethnographically-informed reflections successfully cast doubt on notions of enculturation as hierarchical and linear. In particular, her research on students in an MA program in TESOL and a PhD program in sociology show that the trajectories of her participants into more “expert” scholars and teachers were “characterized less by authority and certainty than by change, uncertainty, self-doubt, and growth” (pp. 10-11). The game metaphor is resonant throughout, and Casanave’s results suggest that the more successful students were the ones who were able to see their enculturation as a kind of game, while the less successful saw enculturation in terms of the slavish following of disciplinary rules. Heuristically, Casanave initially adopts the “communities of practice” (CoPs) model as the game-context, positing game play as the function that moves novices from the periphery to the core. This modification of Lave and Wenger (1991) works to some extent, but is more successful at making sense of the games that remediate novices into experts (in her chapters on students) than in unpacking the playful engagements through which existing experts continue to grow and change (in her chapter on faculty). As Casanave admits,

From a disciplinary community perspective, I could not recognize a center toward which the four [faculty] participants were gravitating in their respective fields, nor did any of them appear to be seeking a disciplinary center. The…metaphor does not reflect the realities of the local and…necessarily peripheral nature of academic writers’ participation in their fields’ scholarly activities. (p. 213)

Part of the problem is that the metaphor of “legitimate peripheral participation” (LPP) represents enculturation trajectories as linear: legitimacy of practice (increasing over time) is inversely
proportional to novelty. However, with this model, once one becomes an expert, there is nowhere else to go. In this way, Casanave reveals both a key flaw in CoPs and LPP conceptions of enculturation and a key advantage to the notion of game-play, which has a habit of turning constructs like “legitimacy” and “periphery” inside out and upside down.

If we take Casanave’s conclusion one move further, we begin to look beyond casting game-play as a mere mechanism of some other model of social practice. Thus, play becomes the frame and the object as well as the function of the game of enculturation. As illustration, I present three enculturation games currently at play in the College of Engineering:

1. First, there is play in the rules, meaning that rather than being rigid and fixed, disciplinary writing rules are frequently open for interpretation, meaning different things for different people and in different spaces and contexts.
2. Secondly, there is (inter-)play between disciplines, meaning that texts routinely cross disciplinary boundaries, and many key acculturative experiences are structured through seemingly extra-disciplinary writing, reading, and speaking activities.
3. Finally, instructors and students routinely play with notions of “academic” and “real world” spaces, deploying these conceptual realms as part of a strategic learning game.

Through the lens of enculturation games—the instances of messy consanguinity and utter estrangedness—we begin to achieve a more comprehensive view of participants’ fluid, idiosyncratic practices as they form, as Wittgenstein would say, a kind of “family.”
Playing by with the Rules

In comparison to all of the other students I interviewed, Matt struck me as the most at odds with the disciplinary persona of an engineer. At the time a junior in mechanical engineering, Matt surprised me with his offhanded account of his decision to enter the program:

I didn’t really think too much about college until I was a senior [in high school]. I just sent out a bunch of applications, got a bunch back, and then at that point decided where I wanted to go. So I decided at that point that I would do engineering based on…not very much, really. So it really wasn’t like a big decision I made. It’s just that I checked something on my application. I’m sure a lot of people have more intricate stories than me, I just kind of went with the flow, I guess.

Not only did Matt seem lukewarm about his path into engineering, he also described himself as not particularly enthusiastic about his career options once he finishes up the program, “I don’t know, I don’t really want to be an engineer,” he sighed, “I don’t know what type I am, but I’m not the engineering type.” But despite his lack of explicit enthusiasm for the field, it was clear that he was a very successful engineering student.

Twice during our conversation, Matt’s phone rang—fellow students calling Matt to ask questions about the lab report (an excerpt of which is in Figure 3.1 below) they had been assigned to turn in for the next day of class. Matt efficiently reiterated the goals and requirements of the assignment to his classmate and added some suggestions for how to negotiate the most difficult part of the assignment, the “Results and Discussion” section:

The two main things I wrote about were—there were two sections that didn’t get made by the machine because it was too narrow for the bit to fill, to fit through. So the little circles around the eyes, which you can see on the part, they didn’t
actually get made. So that was one major thing. And another was that there were these little lines on the final part, which you can see in the picture, and that’s left by the drill bit, it shows the line of indentations, of etchings where the drill bit path was, know what I mean?

3. RESULTS & DISCUSSION

3.1 Final Milled Piece
The final milled piece showed some interesting features. While the top surface is smooth to the touch, visually it doesn’t look smooth. The inside of the cut is ridged with the lines left by the drill and is rough to the touch. The curved edges on the inside of the deeper cut are surprisingly well formed, although slightly altered by the aforementioned ridges. The cuts made are mostly symmetric and nice-looking, but there are a few lines where the drill would move across the cut from one side to the other and left a line. The rounded edges on the bear’s face appear to have been difficult in machining, as they have a relatively small radius and transitioned into the portion of the cut that was too narrow for the drill to fit in.

3.2 Differences Between Model and Final Part
Observation of the final product shows several interesting results. Most noticeably, the eyes that were intended to be cut into the block didn’t turn out. This was because of a fault in the original Pro-E design, namely that the drill wasn’t able to fit into the small space left for the eye. Another thing that stands out as different are the small indentations left by the tip of the bit as it cut out the pattern. These indentations follow along with the drill’s path, showing the line it took in the part’s fabrication. Other than the significant flaw and the small lines left by the drill, the final design, shown in figure 1a, closely mimics the model shown in figure 1b.

Figure 1- a) Pro-E Model of Part, b) Final Milled Part with Defect Area Highlighted

One more area that didn’t come out completely as expected was the nose, which was modeled as a cylinder with straight edges, and came out rounded. This is visible in figures 2a and

Figure 3.1: A page from Matt’s lab report on computer aided design and manufacturing.
As we can see in Figure 3.1, Matt’s “Results and Discussion” section successfully accounts for the differences between the design of the model and the final milled part. Thus, Matt is not only sufficiently expert to produce effective lab reports, including the most difficult section, but also proficient enough to explain to another student how to execute the genre.

Even more interestingly, Matt’s lab report is much more playful than it might seem at first glance. The assignment specified that Matt produce a design, translate the design into machinable code, send the code to the milling machine, and record his methods and results in a lab report. Matt selected a design with a great deal of personal significance and was able to re-engineer the assignment into something that was interesting and fun. When we take a look at a close-up of Matt’s lab report (see Figure 3.2), we see the old Chicago Cubs logo, which was only used from 1962-1978, more than a decade before Matt was born.

The game of baseball permeates many things that Matt does on a day-to-day basis. He considers himself a baseball enthusiast first and an engineer second, and he hopes to find a career in Major League Baseball after graduating. He confessed towards the end of our conversation:
Well actually, I’m a big baseball fan, and that’s always kind of been my secret dream job, as I’m sure a lot of baseball fans have the same fantasy. Obviously there’s the whole equipment part that needs to be engineered. So that’s something I’ve looked at. There’s also a lot of physics behind baseball, which isn’t quite engineering, but the same general area. And there’s a lot of statistical analysis in baseball. So I mean, none of those are really engineering, but nicely tangential.

Read in this way, Matt’s lab report transforms from an instance of bending the rules of a seemingly impersonal, rigid genre into a record of Matt’s ability to play within the constraints of his enculturation and professionalization as an engineer.\textsuperscript{13}

In her conclusion, Casanave (2002) posits “rule-bending” as an alternative way of understanding post-novice enculturation. For Casanave, rule-bending is a playful, feminist practice characterized by movements not upwards or inwards, but “in other directions (sideways? In circles? Zigzag? Out?)” (p. 220). Indeed, rule-bending seems to be a key practice at play in many humanist and social science disciplines, as numerous feminist scholars have argued that attaining disciplinary legitimacy requires us to challenge disciplinary authority (Jarratt, 1998), to learn how to break the rules (Richardson, 1997), and to do so in rhetorical ways (Haraway, 1991). However, though it may surprise proponents of Biglan’s (1973) and Becher’s (1989) view of “hard-applied scientists,” playful rule-bending is also a routine feature of knowledge production in engineering, even when it comes to some of the most “purposive”-seeming genres like the lab report.

The lab report is well-researched both within and outside of rhetorical studies (Myers, 1990; Dias et al, 1999; Swales, 2004; Beaufort, 2007; Carter, 2007; Devitt, 2008; Alaimo et al, \textsuperscript{13} I explore practices of personalizing disciplinarity more fully in Chapter 5.
Though it is neither the only nor the primary form of writing assigned by faculty to students, it is likely to be the most recognizable and readable to outsiders; lab reports combine technical lexis with alphabetic text in ways that are often more easily understood by lay readers than are primarily mathematical, symbolic statements and graphs. Perhaps for these reasons, the lab report has been overrepresented to such a degree that it has come to stand in as the symbolic, ur-text for all scientific and technical writing. Not only has this emblematization averted research on other technical genres (including many other kinds of everyday inscription like graphs, programming code, emails, diagrams, in-class notes, etc), it has also contributed to readings of the “rules” of lab reports as fixed, stable, and impersonal.

Our misconceptions of the rules for certain disciplinary genres as rigid and neutral are particularly striking when compared to the texts and thoughts of engineering students and faculty. In fact, lab reports contain many surprising instances of what we might think of as simultaneously playful and disciplined writing. Take for instance some language concerning lab reports touted by the writing center at my institution:

The belief encapsulated in this axiom, that science abhors the first person, is a central tenet of the folklore about scientific and technical writing. For writing center tutors at UIUC, most of whom are nontechnical, these tips have become the gold standard in advice to give to students in need of help with their lab reports. But this presumed stable goal is not so uniformly suitable for all lab reports, and is by some faculty actively discouraged.
David is a professor of materials science and engineering who has taught many lab-centric courses during his tenure at UIUC. When I asked him to explain his guidelines for lab report writing, I was stunned by his advice to students. The first page of David’s lab-report writing guide for students (Figure 3.4 below), uses second person active voice, reading, “You should also introduce how you did the experiment: i.e., briefly describe the approach and the instrumentation that you used to collect the data” (emphasis mine).

Figure 3.4: Writing guide for David’s mechanical science and engineering class, Fall 2009.
When I asked David to explain this language and to talk about his position on writing in first and third person and in active and passive voice, he exclaimed,

The main thing is “don’t use the third person!” It makes their sentences clunky and confusing and it’s impossible to tell who did what. Is this something that the student did? Or your TA? Or are you talking about something another scientist had done in a prior study?

David’s explanation of why students should use the first person when writing up their results concerns his ideas of intellectual property, which call into question the kind of scientific writing folklore about neutrality and impersonality encapsulated in the writing center’s “Key Tips for Science Writing.” By contrast, David believes that scientists and engineers cannot assert ownership over their findings and methods without grammatically exerting their individuality. And while he is also concerned about the “clunkiness” of writing in the third person and in passive voice, his encouragement to students to use active first person in their lab reports is not only for reasons of readability.

As an active researcher as well as an instructor of engineering, David works hard to connect his students’ school practices to his own professional practices. He explained,

If you did it, you need to say that YOU did it. And I guess that’s another important part of it, is that you have to take credit for the work that you have done. If you don’t take credit, you are being too humble. When I write papers for publications, I use the first person.

To illustrate his point, David pulled a photocopied article off the top of a stack of papers on his desk (Figure 3.5). There, on the first page of a co-authored article he published in *Science* a few years ago, are indeed numerous instances of first person active voice: “We attribute,” “we
demonstrated,” “We synthesized,” “We purchased,” “we determine,” “We used,” “We examined.”

Figure 3.5: First person active voice in an excerpt from one of David’s professional publications.
While some writing researchers have expressed skepticism about the relevance of writing in school to writing elsewhere in the world (Carter, 1993; Dias et al, 1999; Beason, 2001; Downs & Wardle, 2007), David’s case evidences a much more nuanced and complex enculturation game.

In addition to training his students to take credit for their own actions and decisions in the course of their experiments, David puts much effort into teaching students to write the “Results and Discussion” sections of their lab reports. While he is frequently satisfied with the kind of writing students do in other sections of the lab report (Introductions, Materials, Figures and Graphs), he notices that students are reluctant to integrate personal interpretations (possibly because they are elsewhere receiving the same bad advice reified by the writing center). He actively works to counteract students’ impulse to list results mechanically and render themselves invisible and routinely asks students to focus their revision efforts on the sections that require they be “present” in the text:

![Figure 3.6](image)

5. **RESULTS AND DISCUSSION**

“Results and Discussion” will comprise the majority of your report. In this section, you will present your observations, data, and analysis of the data in a logical order, usually organized by the order in which you acquired the data. We recommend that you avoid the use of tables in this section; an x-y plot of the data is much more useful in showing the connections between variables. If possible, you should compare your results to theoretical expectations and accepted values. The discussion will also include an analysis of random and systematic errors. A typical length for this section will be 4 pages of double-spaced text but, depending on the complexity of the experiment, more text is sometimes needed.

*Figure 3.6: Excerpt of writing guide distributed by David to his students, Fall 2009.*

While there are certain rules to writing a good lab report for David’s class, part of the game is in differentiating the more strongly rule-bound sections from those that allow for some play.

Playing with the rules, then, is not a practice restricted only to soft sciences or to disciplinary “experts.” Moreover, as we can see from Matt’s baseball-themed lab report, playing with the rules is not only an enculturation strategy, but also a source of enjoyment, of fun.
Disciplinary Permeability

On my first visit to Philip’s engineering class, I sat off to one side of the room in an attempt to be innocuous. But I might as well have stood on top of a desk in the front of the room, as Philip introduced me to the class and told the students how my research related to the mission of the class, Ethics and Engineering. He read aloud from the syllabus, reminding everyone present of the core learning objectives.

Course Objectives

- To read and think critically
- To develop moral reasoning skills
- To improve writing skills in an engineering context
- To understand multiple perspectives and to respect others of diverse persuasions
- To study the fundamental structure of human personhood, the grounding of moral action, and the development of moral character as the precondition of integral performance in a profession

Figure 3.7: Learning objectives from Philip’s syllabus, distributed and read aloud in class.

“From a metaphysical perspective,” Philip explained, “these objectives are the same.” Though these may seem like strange words for an engineering class, Philip frequently makes such references to issues of morality and character in his course. He is a tenured part of the engineering faculty and has been teaching this class for a long time, but his background is in philosophy. Philip works hard to make his students— for the most part, all engineers—think about the philosophical implications of their words and actions.

To illustrate his point about the interconnectedness of good writing and righteousness, Philip passed out fuchsia-colored handouts, and began reading aloud again.
He paused right after reading the first line to re-orient the class to a text they had begun reading several weeks before. “Remember,” he said,

…they are nearing the exit, but how are they going to get out? This is the main question, and that’s the context of Frodo’s dilemma, and of Tolkien’s story.

There’s context for everything, and there’s a context for the principles of effective writing… So, anyway! Frodo sees before him this black chasm, meaning they’re almost out! But, at the end of the hall, the floor vanished…

However disoriented I had been with Philip’s metaphysical opening for the class, I was even more surprised by his students’ reactions as their teacher read aloud in a dramatic voice from J. R. R. Tolkien’s *Fellowship of the Ring*. But for these students, reading fantasy literature in class was business as usual. As they listened to Philip’s recitation, some nodded their heads slightly, while others jotted notes on the scene at the fictional bridge of Khazad-Dum. What is Tolkien doing on an engineering syllabus, I wondered? How did it get there?
Upon closer inspection, this particular excerpt from Tolkien’s *Lord of the Rings* trilogy did seem to smack of engineering issues: the building of bridges, the construction of civic safety, considerations of material science, strategies for confronting obstacles, technologies of war, etc. We see as the narrator assesses the physical properties of the space: “Suddenly Frodo saw before him a black chasm. At the end of the hall the floor vanished and fell to an unknown depth.” We are encouraged to consider the civil and material engineering of the door and bridge: “The outer door could only be reached by a slender bridge of stone, without kerb or rail, that spanned the chasm with one curving spring of fifty feet.” Engineering also provides a powerful lens through which to interpret the physical settings and the principles of their construction: “It was an ancient defense of the Dwarves against any enemy that might capture the first hall and the outer passage.”

Thus, through close reading, we might argue convincingly that *The Lord of the Rings* was “always already” an engineering text. Philip, however, does not identify thematic analysis as a key motivator for his inclusion of Tolkien on his syllabus:

I’m motivating them to pick up Tolkien! To see that at critical moments in the narrative, Tolkien brings all the powers at his disposal, the skills that he has acquired. The bridge of Khazad-dum is one of these moments, this eloquent picture that’s before you. Tolkien is doing that throughout the three-volume narrative. He crafts this image that you can actually see—you’re there with Tolkien. And the encouragement to every member of the class is that when they are out in their jobs, and in the contexts of their lifecourses unfolding, that communicative skills are absolutely essential.
Philip acknowledged during our discussion that writing a novel is different from writing an engineering report, but emphasized how Tolkien can teach engineering students to value language:
To reach your communicative potential, the ability to take that moment in your dialogue with your advisor or your colleagues, and to bring them into where you are, into the research, and to use language to articulate [to them] what needs to be done. It’s absolutely essential. So it’s a different mode of using language, but the hope is that—how do we learn to write and how do we learn to speak and to use language—is to see how someone else has done it.

Thus, Philip considers the Tolkien book, as a fun and enjoyable read, to be a source of inspiration for engineering students. From Philip’s perspective, communication is an essential component in his classroom, and he feels compelled to bring multiple resources into play—philosophical discussions, essay-writing assignments, technical readings, and literary fiction—to convey this lesson to students.

When I asked Stephanie, one of Philip’s students, to explain why she felt her professor was using *The Lord of the Rings* in an engineering class, she answered by way of bringing up two other assigned readings: Kate Turabian’s *A Manual for Writers* and Joseph William’s *Style: Towards Clarity and Grace*. Stephanie’s response communicated a wealth of information, not only about Philip’s class, but about playful elements of enculturation and the interplay between engineering and other disciplines:

Well, we read five thousand books for this class—but that’s okay! With Tolkien, he’s basically showing us descriptive writing. I’m a big *Lord of the Rings* nerd, so I enjoyed that part. We also had Turabian’s writing manual, which I found really useful. Because it’s an advanced composition credit, it’s also a writing class, and he’s tried to teach us effective writing skills, as well as ethics, and philosophy, which is nice because it combines everything. I’ve learned a lot.
While Stephanie regarded the Tolkien readings as merely entertaining, she identified the Turabian text as constructive of the development of engineers, further underscoring the centrality of interdisciplinary play to processes of enculturation.

**Figure 3.10**: A lab report writing handout from David’s material science and engineering course.

---

It is not unusual for engineering faculty to be proponents of humanist writing handbooks, encouraging and even requiring their students to use them. In fact, all but one of the professors I interviewed mentioned their use of some edition of Joseph William’s text, and in Figure 3.10, we can see that David, the material science and engineering professor, mentions Williams in his lab-report writing guidelines. Though William’s writing handbook was the most frequently identified by my faculty participants, the Turabian manual is notable for at least three reasons: it is highly local to UIUC, the author is a woman, and she was a secretary when she wrote it.
Turabian, who passed away in the eighties, wrote her manual when she was working as a secretary at the University of Chicago.

Moreover, the use of Williams and Turabian is a strong indicator of the uptake of “non-engineering” texts in engineering contexts, which troubles the discrete model of disciplinarity. The use of Turabian, however, is particularly interesting, because unlike Williams, Turabian is more local to UIUC than to “engineering in general.” Moreover, Philip’s inclusion of her manual implicates not only non-engineers but also women and non-academic staff into the enculturation of engineers. In sum, Turabian’s manual is not a widely-used handbook for engineering students, and, as a woman, Stephanie is not representative of average engineering students. Moreover, Philip, as a trained philosopher, is not a typical engineering teacher, and his central course texts, Tolkien’s *Lord of the Rings* trilogy, is not representative of the average engineering text (or even the average literary studies text, for that matter). Together, Turabian, Stephanie, Philip, and Tolkien show the deep interplay between disciplines. Not only do texts like Williams, Turabian, and Tolkien routinely cross disciplinary boundaries, many key acculturative experiences (learning to express what it means to be an engineer) are structured through seemingly extra-disciplinary writing, reading, and speaking activities (e.g. drafting and presenting texts on the ethical responsibilities of an engineer). Through this enculturation game, we can see how disparate texts and practices come together to form a kind of engineering family, albeit an intensely interdisciplinary one that shares resemblances with many other practitioners, practices, and texts both associated and not associated with engineering.

14 She has, as you will read in Chapter 5, recently changed her field of study to kinesiology.
No True Engineer\textsuperscript{15}

In some ways, Harry’s course functions identically to Philip’s, providing an in-house opportunity for engineering students to satisfy the Advanced Composition requirement and serving as capstone-like experiences. Both courses are designed to teach students to write, read, and speak like engineers. But both also aim to go beyond teaching language and writing skills, arguing for a view of engineering as something greater than its technical content, lexis, and protocol. Nevertheless, there are sharp differences in their teaching philosophies. While Philip sees his course as an opportunity for engineers to develop critical and moral consciousness, Harry wants to teach his students to be street smart: at the core of his teaching philosophy is a desire to make his courses contiguous with the disciplinarity of “real world” engineering.

During our interview, Harry frequently used the expression “real world” to distinguish certain engineering practices from those he associates only with school practices. The term also extends to his distinction between the engineering faculty with commercial engineering experience and those with primarily academic backgrounds:

I was a consultant in industry for about ten years, for US Army Research Laboratory, we had to do these academic reports, because the majority of their researchers were either faculty then or had been. And they would do good work, but they didn’t care one bit about technology transfer. They were guys who wanted to go out there and play with the technology. It was a solution looking for a problem. \textbf{It’s not like they were engineers trying to solve a problem and looking for the solution. They were researchers.} [emphasis mine]

\textsuperscript{15} Affectionately adapted from Antony Flew’s humorous logical fallacy about “no true Scotsman” in \textit{Thinking About Thinking} (1975).
Of all the faculty, students, and staff interviewed in the course of this research, Harry was the only one who identified himself, quickly and confidently, as a “real” engineer. He compared himself in this way to other engineering faculty, explaining that most of the people responsible for teaching engineering students have never actually worked as a “real world” engineer: “The whole purpose of an engineering education is not just to read a bunch of textbooks, do homework problems, prove you can do this teeny little thing in a teeny little area of engineering.” For Harry, a lack of non-academic experience in faculty becomes detrimental to students, who are then trained to become academic rather than commercial engineers. Harry’s problem with engineering education is that he believes academic engineering faculty teach narrowly-focused engineering problems related to their own research. Assigning such well-defined problems, Harry says, leaves no room for students to develop what he calls “engineering insight”:

We give them so much information, and then we have them solve one little piece of a very defined situation. And many of the students end up learning how to solve these very very focused engineering problems, but they may not learn the engineering insight. In other words, given an extremely broad situation, how do you design a system, use your insight, and make big global decisions about how you would approach it? What I’m trying to do is to prepare the students to work in a commercial engineering environment. That’s where the majority of them work now.

Here we see the interesting way in which Harry deploys the seemingly distinct notions of “academic world” and the “real world” to frame the space of an enculturation game. In Harry’s game, it is possible for an instructor to be a “real-world” engineer even if he or she is currently
working in a primarily academic capacity. It is also possible to be a real-world engineers even if one have not yet graduated with a degree in engineering or begun work as a professional engineer; the game also casts students as Harry’s real-world engineering allies, since that is where he believes the majority of them will end up working.

Another feature of Harry’s enculturation game is that it is possible to teach elements of the “real world” within the context of the “school world.” This is what he feels makes his course so unique:

One thing that’s different about this course is that we don’t correct a terrible report by giving a low grade; we just say, “you’re not done. You gotta rewrite this.” I don’t give anything lower than a B. This course they also can’t drop.

Once you’re in it, you’re in it. This is a real-world course.

Within the game-sphere, the two worlds can even share genres. Harry talked at length about one genre—the presentation—shared across both contexts. In his advice to students, Harry deploys the real world space to illustrate that the stakes of writing a presentation should have the same urgency whether it is taking place in a classroom or a boardroom. In addition to developing “engineering insight,” learning to write presentations and other kinds of “real-world” reports is an explicit objective of Harry’s enculturation game. Whether inside or outside the game space, Harry sees effective communication as a crucial part of learning to be an engineer:

I’ve seen zillions of presentations, and it seems to me that the goal of the person presenting in a university setting is to say “I’m really smart, but I don’t care one bit if you can understand anything I’m talking about.” Well that person would be completely ineffective in the real world. In the real world, the engineer should be able to make the complex simple.
His game revolves around writing and speaking as a “real-world” engineer because he is particularly pessimistic about his students’ communicative abilities:

Kids through high school, they don’t read and they don’t write very much, so we have kids who come to us and their verbal abilities are not very good. They speak and write in very simple sentences, like I did when I was in seventh grade. Seniors in college are writing like: “Jack and Jill went up the hill.” Period. Not even “to fetch a pail of water.” Just “Jack and Jill went up a hill. Jack and Jill went there to get water. They wanted to fetch a pail of water. Then they came down.”

Harry’s reference to the Jack and Jill story is interesting on several levels. On the surface, the allusion to the popular nursery rhyme conveys an estimation of literacy as a rudimentary and obvious skill—an attitude that contradicts Harry’s clear investment in engineering literacy. Moreover, the reference emphasizes Harry’s distress at the linguistic immaturity of contemporary college students, while also expressing the playful air he enjoys presenting to students.

In Harry’s enculturation game, there are clear allies and clear enemies. Allies of “real world” engineers include himself, his students, his course, as well as certain other allied disciplines, like marketing and economics. Harry feels so strongly about the relevance of marketing to engineering that he is compelled to dramatize the relationship:

Every semester, I ask them to raise their hands “who’s in engineering sales or engineering marketing?” Those are secondary fields here, so they can get both degrees by taking four courses towards marketing. And maybe three or four hands go up. And I look at them and say, “you know what, you’re ALL in
engineering marketing.” You have to be able to market your ideas. If there’s an integral component you have to communicate to the rest of the team, and you can’t sell them on the validity of your ideas, why they are important, why they should be adopted, they won’t see that you’re producing any meaningful work product…and you won’t have a job! You won’t feed your family.

Communication is absolutely vital. You’re always selling your ideas.

Here, Harry uses the word “vital” both figuratively and literally. Communication is vital in the sense that it is an imperative skill for success in engineering. It is also vital in the sense that it uniquely determines one’s ability to earn the revenue necessary for feeding and sheltering one’s spouse and children.¹⁶

Given Philip’s interdisciplinary enculturation game, we might also wonder if Harry’s reference to eighteenth-century British verse (“Mother Goose”) implicates literature in the education of engineers. Harry would almost certainly say no, as literature, unlike marketing, is an enemy combatant in his enculturation game. He feels very strongly that we should distinguish literary writing from the kinds of communication that engineers do:

I would like students to not only to develop the engineering insight but to be able to speak in complete sentences, to tie logical ideas together. However, in engineering, if you’re going to write an engineering docket or a report, if you can say it in five pages or say it in one paragraph, the better thing is to say it in one paragraph. We’re looking for an efficiency of words, for information-dense

¹⁶ Moreover, though probably not intentionally, Harry’s mention of the “vitality” of communication conjures up masculine and heteronormative notions of labor, engaging societal norms of home economics in the enculturation of his engineering students.
paragraphs. We’re not writing novels, we’re not trying to give people a break from reality. Engineers don’t want to read a lot of fluff.

For Harry, the distinction between literary and engineering writing comes down to breadth versus brevity, which, while playfully reductive, also suggests a certain ambivalence\(^\text{17}\) towards what constitutes good writing in engineering. On one hand, he has already said, “In the real world, the engineer should be able to make the complex simple.” But on the other hand, here he is concerned that students can only “speak and write in very simple sentences” and that their tendency is to break complex ideas down into step-wise kernels (“Jack and Jill went up a hill. Jack and Jill went there to get water.”) In fact, there is even more play between the “worlds” of academia and commercial engineering, and between engineering and literature than Harry alludes to in his enculturation game.

The “Iron Ring” ceremony, which originated in several engineering colleges in Canada in 1925, is an excellent example of the playful acculturative relationship between school worlds and academic worlds. The ceremony has become increasingly popular in the US since the early 70’s, and in the last few years, numerous local Engineering firms in the Champaign-Urbana area have started requiring their employees to return to UIUC to participate the “Kipling Oath.” Just after

\(^{17}\) In fact, his ambivalence captures one of the most notorious problems in communication theory, famously treated by Tufte (1983) as the problem of “data-ink ratio.” In short, Shannon and Weaver’s (1949) transmission model argues that redundant information is crucial to ensure effective and complete transmission of information: due to the presence of play or “noise,” communicative transfer must account for data loss during the course of transfer, meaning that some amount of (calculated, optimized) redundancy is more desirable than total succinctness. But, as Tufte and many others (Reddy, 1979; Lakoff & Johnson, 1980; Bowers, 1988; Carey, 1989) have pointed out, human communication and computer communication are quite different. Because human brains have subjective and contextual methods of interpreting, interpolating, and adapting to partial information, the conduit metaphor is an especially a weak representation of human-to-human “data transmission.” Nonetheless, modern technical writers (e.g. Alley, 1993) tend to agree that absolute concision is generally not desirable in communication across different levels or areas of expertise and differential access to specialized vocabulary.
writing “The Sons of Martha,” Kipling produced this oath at the bequest of a Canadian engineer and inventor named Herbert Haultain.

Figure 3.11: Program for the February 2006 “Order of the Engineer” ceremony.

Figure 3.12: Opening paragraph of the “Order of the Engineer” oath.

18 Discussed extensively in the Introduction.
The Kipling Oath resembles the Hippocratic Oath that doctors take after enculturation into medical school, and is part of a secret Engineering ceremony known as “The Calling of an Engineer.” The oath-taking ceremony involves placing one’s hand through a large iron ring while pledging allegiance to the maintenance of public safety. Many ceremonies close with a reading of Kiplings’ poem, “The Sons of Martha,” as inductees are given a stainless steel ring to wear on the pinky finger of either hand. Traditionally, the ring is slightly barbed, so as to serve as a constant reminder to the wearer of his or her burden as a child of Martha.

One particular line of the Kipling Oath, about “the heritage of accumulated experience,” (visible in Figure 3.12 above) suggests an explicit nod to the process of enculturation. The line is notable for several reasons, not least of which because it represents enculturation as something more dissolute (“accumulated experience”) but also more profound than mere education (“heritage [without which] my efforts would be feeble”). The line also seems to encourage oath-takers to be conscious of the heritage of their discipline—though this heritage might in fact disrupt certain conceptions of the discipline. Consider, for instance, the qualities that the Iron Ring ceremony “inherits” from the disciplinarity of the oath’s author. Kipling was, of course, not an engineer in the conventional, conservative sense (though his masonry experience might qualify him if we take a flat CHAT perspective). His other writings include *The Jungle Book*, “White Man’s Burden,” *Kim*, and the *Just So Stories*—which is why Kipling is famously known as the “Bard of British Imperialism.”

Not surprisingly, both “The Sons of Martha” and the Kipling Oath are based in Judeo-Christian theology and Western notions of good, evil, faith, and righteousness. The texts are also gender normative; Kipling makes no mention of the daughters of Martha. For these reasons, it would seem more than a little ironic to find such photographs as the ones in Figure
3.13 advertising the Iron Ring ceremony on the engineering homepages of many institutions. In light of published data about the demographics of graduation rates in engineering programs, these photographs suggest a visual overrepresentation of women and racial, religious, and ethnic minorities. These pictures are departmental PR. Yet, despite what looks very much like advertising, the Iron Ring ceremony is supposed to be a secret one.

![Figure 3.13: Iron Ring ceremonies at Trinity University and the University of Toronto.](image)

It is not mere coincidence that the schools advertise the “secret” ceremony with pictures of a dark-skinned male Sikh and three multicultural women. Disciplinary stories are served by linear narratives of progress, resulting in a particularly dangerous enculturation game. In this game, the double mystification aggressively publicizes tokens of “progress” (through photographs like the ones in Figure 3.13) and cloaks histories that otherwise detract from linear models of progress. Thus, with the enculturation games heuristic, we are better able to answer

---

19 Discussed more fully in Chapter 5.
20 In fact, Kipling’s poem, oath, and ceremony were not conceived in a time when only white men could be engineers. As early as 1896, George Washington Carver had been doing what we now call “agricultural engineering” in his laboratory at the Tuskegee Institute. Around the same time, Lewis Latimer had already obtained six patents; Latimer was an African-American inventor and former slave who went on to work with Thomas Edison and Alexander Graham Bell, making major contributions to our knowledge of electric light filaments. Women have also been engineering since well before the publication of Kipling’s poem. Nora Stanton
Jarratt’s (1998) call to challenge “disciplinary knowledge by pointing out its ideological investments, particularly investments that sustain oppressive social structures and relations of economic exploitation” (p. 2). By understanding enculturation as a game instead of a hierarchical or linear progress model, we are better able to identify and reflect on acculturative practices not only at the level of individuals, but also in terms of the patriarchal institutions and broad, systemic racisms that are always in play. As we can see in the dark and messy history of the Iron Ring ceremony, play is much more than a synonym for fun. And even in cases where explicit play is taking place, the enculturation games at work are often much more complex.

**#1: The Dear John Algorithm** Lawrence is, without question, one of the most popular lecturers in the computer science program, and it’s easy to see why.

```java
public static void main(String[] args) {
    String [][] letter = {
        {"Hi", "Dear", "Dearest"},
        {"Mike", "Jenny", "sugar", "sweetheart"},
        {"\n"},
        {"I can no longer", "I want to", "I need to"},
        {"think", "swim", "break up", "sing country music"},
        {"for you.", "with you.", "about you."},
        {"\n"},
        {"Bye.", "Your loving friend,"},
        {"\n"},
        {"Jenny", "Jim"}
    );
}
```

*Figure 3.14: In-class handout for Lawrence’s lecture: “Using Multi-dimensional arrays.”*

Blatch graduated from Cornell with a degree civil engineering in 1905, and Ellen Swallow Richards, who graduated from Vassar and MIT at the end of the 19th century, went on to found the field of environmental engineering.
The youthful, engaging British transplant relishes the use of humor to get his lesson across, assigning students to write, for instance, a random lover-letter generator in order to teach them complex engineering concepts:

They really like this [assignment], which prints out a random love letter. I mean, you’re eighteen, what do you care about? True love! Or perhaps more base versions of that. But I can talk about true love in a safe way in lectures. So here you are, maybe you’re thinking of splitting up with your girlfriend from high school, maybe you like someone else from your dorm, or whatever. Let’s do something useful for you. So here’s a program that’s going to write a love letter or a breaking up letter for you.

For Lawrence, the game is to bring students’ lived realities (“real world”) into the classroom (“school world”), to make the engineering enculturation feel maximally relevant. Here is an immediate family resemblance to Harry’s enculturation game, as well as the games of David and Philip.

Lawrence is quick to point out that there is a larger purpose to the random-letter generator: it is a particularly good way to illustrate the concept of ragged arrays, a popular way of arranging different data types so they can share the same kind of digital space.

So what am I teaching? I’m teaching ragged arrays. In Java, different sub-arrays can actually be different lengths and how can we extract randomly one element from each of those? Well, [our letter generator will] pick a random word, the first line is ‘hi,’ ‘dear,’ or ‘dearest,’ and then ‘Mike,’ ‘Jenny,’ ‘sugar,’ or ‘sweetheart.’ At the end of lecture I run this on my machine, so they see it live. I solicit some names from them so they’re involved and connected to it. And you run it a few
times and it produces some silly letters. They love it, and they request the code, and they want to play with it.

Like Matt, the baseball-loving engineering student, Lawrence feels only marginally tethered to rules. He is always looking for ways to teach what he calls the “dry stuff” in playful ways, even if he must violate some rules of decorum by engaging his students’ love lives in a public forum. He wants his students to enjoy class time and homework as if they were at play, rather than at work.

Like Philip’s introduction of philosophy and literature into his engineering ethics course, or David’s adaptation of William’s humanist style handbook for his students’ lab reports, Lawrence’s learning objectives also borrow heavily from other disciplines, including cognitive and educational theory:

I don’t want to teach syntax. I want the large lecture time as much as possible to be treated like a small classroom experience, and to be working on the higher levels of Bloom’s taxonomy—not just recall, but application and debugging—so you have to know what all the pieces do in order to resolve that problem. The art of the instructor is to try and find problems that make sense in just five or ten minutes.

Lawrence is, thus, playing all three kinds of enculturation games. What’s more, he successfully infuses the atmosphere of his courses with play, frequently using the word “play” to describe the ideal learning context for an engineering class.

#2: Caveat rhetor Like Philip’s engineering ethics course, Laura’s engineering law class is easily identifiable as an interdisciplinary game space. When I asked Laura, a former
lawyer, whether she ever has any trouble communicating with students across the disciplinary divide, she invoked the “real world/school world” game to explain the first lesson she does each semester. She begins by asking the students which is the best restaurant in our town, and after taking several suggestions and writing them down on the board, asks the students to deploy academic rhetoric to make a case for their favorite. Afterwards, she tells them:

See, you know how to do basic analytical reasoning. What I’m doing is I’m superimposing legal analytical reasoning onto that—not so much because I need you to learn to do legal analysis, but because I’m strengthening your persuasive argumentation skills. The pedagogical challenge for me is constantly reinforcing for the students the basic skills they are getting out of this, in addition to the concrete legal information.

Laura’s juxtaposition of local eateries and academic ways of arguing emphasizes the contrast between the “real world” and the “academic world.” However, she’s also bending the rules by blurring the boundaries between those two spaces: for Laura, the “basic skills” that enable us to make arguments about the “real world” include “street smarts” as well as knowledge gained in high school and in previous engineering coursework. While she admits that she is not overly concerned that her students learn to think and speak like just lawyers, she does want them to retain enough “concrete legal information” to be able to defend themselves against liability when they leave school and begin working as professional engineers.

And yet Laura’s method for teaching students to read and interpret legal writing, built upon her concern for their future professional wellbeing, also underscores a clear interest in play.
Figure 3.15: Legal proceedings from an actual caveat emptor case.

She explains,
The first assignment is real simple: I give them two cases, they’re both fun, one of them involves a haunted house. This guy buys a house in New York, doesn’t know it’s haunted, and once he finds out it’s haunted, he wants his money back.

And it has to do with a very common part of contract law called *caveat emptor*, you may have heard of it, it’s Latin for “let the buyer beware.”

Indeed, knowing ahead of time that the case is about a haunted house renders the legal text (Figure 3.15), to which she requires them to read and respond, somewhat less intimidating.

---

**Figure 3.16**: Laminated bookmark distributed by Laura to her engineering students.
As we can see from her special guide (Figure 3.16), Laura’s stated objective for the haunted house assignment is to teach students how to brief a case:

So what they have to do for this writing assignment is brief the case, to write me an essay and tell me what happens. So for the Stambovsky vs. Ackley case, they have to write a brief—well, it’s not really a brief in the sense that we do in law school, but it’s “write me an essay and tell me what happens” and I give them a series of questions and “if you’ve answered these questions you’ve done the right thing.”

As someone who has practiced law and taught at a law school, Laura is intensely aware that the essay assignment she is giving to her engineering students differs from the kinds of writing assigned at a law school. Nevertheless, she is comfortable playing this interdisciplinary borrowing game because she sees it as a means to an end. Laura’s underlying objective is to teach future engineers to be savvy about concepts like liability and contract law. Similar to Philip’s desire to sensitize students to the moral consequences of engineering, Laura wants students to begin to recognize the far-reaching legal ramifications: “The purpose of a case is not to settle the dispute, it’s to set a precedent. It changes the future.”

Although the context of the case, a rather extreme example of caveat emptor, is what makes it fun for the engineering students to read and discuss, the enculturation game concerns a much more complex blend of rule bending, interdisciplinary borrowing, and real world/school world make believe.
Parallel Play

Enculturation games can include playing with the rules, between disciplines, and across the real world/school world boundary. However, as the previous two cases evidence, it is much more often the case that several types of play are happening at once. Enculturation games routinely occur simultaneously, with some games operating on more concrete, deliberate levels (playing with the arrays in a love letter program, reading Tolkien in an engineering class, spicing up a lab report with baseball) and other operating on highly abstract levels (using Bloom’s taxonomy to teach computer science, assigning literature to inspire metaphysical awakenings, protesting disciplinary constraints by conforming in subversive ways).

Though the playful acculturative phenomena we see emerging in the practices of Matt, David, Philip, Harry, Lawrence, and Laura have, as Wittgenstein would say, “no one thing in common which makes us use the same word for all,” there are, nonetheless, certain family resemblances. In the case of engineering enculturation at UIUC, this family is clearly categorized by what Wartofsky (1979) calls “tertiary artefacts” wherein “forms of representation themselves come to constitute a ‘world’ (or ‘worlds’) of imaginative praxis” (p. 207). What remains to be seen is whether these playful worlds of praxis are also a key feature of the enculturation games in other colleges and contexts, and while it would exceed the scope of this project to explore and describe all of the games in all of the disciplines in all of the institutions, the following chapter will take up the unique world of a very different site of engineering education.
Chapter Four: Writing Across the Curriculum, and the Sea

“Borders? I have never seen one, but I have heard they exist in the minds of some people.”

- Thor Heyerdahl

When asked about his travels and studies across borders,21 this is how the Norwegian adventurer and ethnographer Thor Heyerdahl is reported to have responded. Heyerdahl’s theory of the trans-cultural diffusion of pre-Columbian civilizations in South America to the Polynesian islands, popularized by his 1950 book and 1951 documentary, Kon-Tiki, remains one of the most controversial of modern cultural anthropology. For Heyerdahl, the possibility of such a cultural drift was dependent upon proof that it was possible to navigate a raft across the Pacific Ocean using only Neolithic-era technology. It turns out that such a journey is possible, and cultural drift is plausible.

In the previous chapter, we encountered several instances of cultural drifts between disciplines (philosophy, literature, marketing, law, engineering) as well as drift between institutional and non-academic spaces (baseball, love, industry). This chapter concerns the drift between chronotopes, taking up the discipline of engineering in two very different contexts. Shifting the lens in this way accomplishes two significant goals of this research: first, by providing a richly descriptive local account of the practice of discipline in engineering, and

secondly, by moving us closer to a critical, feminist, and playful remapping of disciplinarity. Thus, in this chapter, I build on the three previous chapters’ efforts to illustrate the complexity of engineering enculturation, while also exploring the nuances that come with a different sociocultural educational context. By examining the texts and textual production practices of faculty, staff, and students at an elite engineering university in France, this chapter aims to put into relief some of the commonalities between the American and French contexts, as well as some of the more unique, peculiar features.

One of the most striking findings from this comparison is that engineering can be profoundly influenced by local cultures, values, and needs; even the kinds of cultural drifts that can happen between two disciplines are highly dependent on local contexts. This is, in a certain sense, what Pickering (1995) intended to capture with his metaphor of the “mangle of practice”:

I find “mangle” a convenient and suggestive shorthand…because, for me, it conjures up the image of the unpredictable transformations worked upon whatever gets fed into the old-fashioned device of the same name to squeeze the water out of the washing. It draws attention to the emergently intertwined delineation and reconfiguration of machinic captures and human intentions, practices, and so on. The word “mangle” can also be used…as a verb. Thus I can say that the contours of material and social agency are mangled in practice, meaning emergently transformed and delineated in the dialectic of resistance and accommodation (p. 23)
Pickerings’ metaphor has been a useful heuristic, and in this chapter, I work to extend his ideas
to the artifacts I gathered during what emerged as a kind of parallel world of engineering. And
yet, while the mangle succeeds in tracing some associations of engineering practice, we will also
see that it breaks down in significant ways.

Mangled Subjectivities

From Fall 2008 to Spring 2009, I was the *maîtresse de langue* (English teaching fellow)
at a prestigious engineering university in France, which is known locally as the “ENSIP.” I
knew from the start that I’d received the job through a quirk in the mangle. At my US
institution, I had been researching the relationship between communication, enculturation, and
disciplinarity in engineering, drawing deeply from WiD/WAC scholarship (e.g. Herrington &
Moran, 1992; Anson, 1993; Bazerman, 1994; Berkenkotter & Huckin, 1995; McLeod &
Maimon, 2000). Curious about how such theories and pedagogies played out in other contexts, I
applied for a one-year teaching exchange program through the French department at my US
institution. This exchange program is famous for privileging scholars engaged in foreign-
language study, but when there are insufficient numbers of applicants, outsiders such as myself
are allowed to apply. In fact, my self-designation as an “outsider” is somewhat inaccurate,
firstly because outside considerations are routinely necessary to fully staff the teaching
exchange, and secondly, because the application process is difficult enough to discourage
applicants who are overly peripheral. And yet, even the teaching exchange recruitment offices
in France and the United States did not share a sense of who would be an “ideal” candidate. A
year later, as I was preparing to return to my US institution, my French colleagues explained that
their *single* criterion for selection was that the applicant be a native speaker of English. In point
of fact, they ultimately rejected their only candidate for my replacement, an accomplished researcher of comparative literature fluent in both French and English, but who was, alas, a native speaker of German.

Thus, my overlapping subject positions, as native English speaker, writing researcher, *maîtresse de langue*, and resident alien in France, both facilitated and complicated my work at the *ENSIP*. In a vague and remote sense, I had always been aware of the act of teaching as a dialogic act of enculturating others and becoming enculturated oneself. In France, this sense was intensely present and difficult to negotiate; I inhabited a liminal space between expert and novice, between insider and outsider, participating in a kind of legitimate peripheral participation (à la Lave & Wenger, 1991) that made me question what we mean when we say “legitimacy” and “periphery.” I was much more keenly aware of my ignorance of my students’ abilities, about the kinds of writing they were doing in and out of their engineering classes, their English trajectories, and their literacy histories.

In turn, my students, who were in the strange position of having to learn to write both as engineers *and* as non-native English users, pushed me to think of disciplinarity in a much more mangled way. I was particularly struck by their negotiations of French, English, and disciplinary literacies, and I was a bit mortified to realize that I had never before seen multilingualism as a legitimate component of disciplinary enculturation. Though I had encountered many non-native English-speaking engineers during my US scholarship, I had never considered the impact that multilingualism might have on the canonic WiD/WAC question, “Can engineers communicate?” (see Herrington, 1985; Winsor, 1996). Needless to say, answering this question becomes somewhat more complicated when the engineers are being asked to communicate both within and outside of their native language.
In their recent talk at the Conference on College Composition and Communication, Gannett et al. (2009) direct our focus to the (figuratively) oceanic phenomenon, of the “waves between continents” in international writing research. Although their message is clear that travel is possible (even inevitable) across the cultural, pedagogical, epistemological, and methodological waters of writing research around the world, Gannett et al. also emphasize what makes such journeys challenging: as with Heyerdahl, our tools are rudimentary, our peers are skeptical, and many competing forces are at work. One key challenge to the international dialogue is that American writing researchers are not often well read in the European, Asian, and Middle Eastern research literatures and are apt to make assumptions about the generalizability (or uniqueness) of American literacy patterns, with little to no inquiry into other cultural and linguistic contexts. The “ubiquity” of ESL/EFL pedagogy around the world is suggestive of an ideology that English is somehow transcendent of boundaries and also fails to capture the totally idiosyncratic, hopelessly tangled mess of practices, histories, textual artifacts, and values that constitute teaching English in any given setting. “Unwieldiness,” as scholars of multilingual writing (Lu, 2004; Canagarajah, 2006; Horner, 2006) suggest, would probably be a more accurate description. For example, one emergent feature of this unwieldiness is that English language instruction, writing instruction, and writing in the disciplines (WID)—under theoretical circumstances three distinct disciplines—have become inextricably entangled on both global and local scales.

In my first few months of teaching English at the French engineering school, I saw neither transcendence nor unwieldiness, only boundaries: boundaries between French and English, between English and engineering, between engineering and other disciplines, and between disciplinary and non-disciplinary writing. As I struggled to integrate foreign language
instruction with the kind of college composition familiar to me from my U.S. teaching experience, I began to recognize ways in which writing in the disciplines and English as an additional language are always already mutually informed. My students and I were constantly adapting familiar practices to new contexts both successfully and unsuccessfully. Our activities as students, instructors, language learners, French speakers, English speakers, engineers, and writers were not worlds apart, but hopelessly tangled up together. It was remarkable to me just how closely the tangle of cultural, material, and disciplinary practices resembled Pickering’s (1995) account of the profoundly complex ways in which histories, values, texts, and technologies collide to form scientific knowledge production.

Scientists are human agents in a field of material agency which they struggle to capture in machines. Further, human and material agency are reciprocally and emergently intertwined in this struggle. Their contours emerge in the temporality of practice and are definitional of and sustain one another. Existing culture constitutes the surface of emergence for the intentional structure of scientific practice, and such practice consists in the reciprocal tuning of human and material agency, tuning that can itself reconfigure human intentions. (p. 21)

As in Pickering’s account of the mangle, it also became clear that temporal, spatial, and cultural context was key: many generalizations I had unthinkingly held onto about “what it means to be an engineer” or “how people learn to write like engineers” were effectively negated by what I learned in France.
Le Tronc Commun (The Core Curriculum)

The main differences between the formal engineering curricula at ENSIP and at UIUC are related to the French and American conventions about the number of years students spend in school; in the United States, most students come directly to college from high school, and then graduate from their engineering program in four (or, increasingly, five) years. In France, the time frame and time breakdown are a little different. Because French high school students are competing for a limited number of spaces in the universities, spaces for which they will not have to pay, there is a tense atmosphere of competition amongst the higher-tracked students. The most prestigious opportunity available to these students are the Grandes écoles, the highest tier of an already highly selective university system. As part of this prestigious system, French engineers must take five years of college-level English (in other words, English is part of the mandatory, fixed curriculum for each of the five years of college-level training). This is after having had seven years of grade school English and passing the written English portion of le bac.

![Figure 4.1: The three-year core curriculum at ENSIP](image)

---

23 Very rough equivalent of the private Ivy League school system in the US. Within the system of Grandes écoles, Colleges of Engineering (usually known as Écoles supérieures d'ingénieurs) comprise some of the most elite degree-granting programs.

24 A required exit exam, which determines in large part who will be eligible to attend university; because of the French system of tracking, several versions of le bac exist, some of which test more heavily in areas of, for instance, math and science or literature.
The undergraduate Engineering curriculum is divided into two parts; first two to three years of *classes prépas*,25 followed by an exam, and then three years at a College of Engineering. Aside from being technically strenuous, *classes prépas* are reading and speaking-intensive (in French) and even include some explicit writing instruction (also in French); thus, in theory, students finish their *classes prépas* with superior technical competence, strong communicational skills, and fair English comprehension. The ENSIP core curriculum (Figure 4.1), as in the American context (Figure 4.2), represents an important part of the enculturation of an engineer and is meant to supply students with basic knowledge necessary to adapt to new engineering contexts.

At both universities, core classes include basics (mathematics, data processing, physics, chemistry, materials science, fluid mechanics, thermodynamics, electronics, heat transfer) as well as more highly specialized disciplinary coursework in things like chemical engineering, electrical engineering, industrial regulation, and robotics. Both universities require students to take course in laboratories as well as in traditional lecture classroom settings. Both make an effort to expose students to the “real world” of engineering with courses such as entrepreneurship, commercial law, economics, and ethics.

While students at both institutions are expected to take courses in writing and culture, the French students are required to take foreign language classes (English mandatory, German and Spanish optional) throughout their time at the *ENSIP*. Moreover, because the French students are expected to graduate in three years, they must take forty hours of courses a week, beginning at 8AM everyday. French students also have far less leeway in their scheduling, again because

---

25 The two or three years of intensive prep classes required for *Grandes écoles*. Written and oral exams establish a hierarchy among students; those with the highest rankings get their first choice of *Grande école*, while the lowest scoring students are eliminated from the running.
of the need to complete coursework in three years, and for this reason, do not have many options when it comes to electives.

<table>
<thead>
<tr>
<th>First year</th>
<th>Hours</th>
<th>First Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>CHEM 102—General Chemistry I</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>CHEM 103—General Chemistry Lab I</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>ENG 100—Engineering Orientation</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>GE 100—Intro to General Engineering</td>
<td></td>
</tr>
<tr>
<td>3-4</td>
<td>GE 101—Engineering Graphics &amp; Design or RHET 105—Principles of Composition</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>MATH 221—Calculus 12</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Elective in social sciences or humanities 3</td>
<td></td>
</tr>
<tr>
<td>15-16</td>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second year</th>
<th>Hours</th>
<th>First Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>CS 101—Intro Computing, Engng &amp; Sci</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>GE 181—Business Stats of Engineering</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>MATH 241—Calculus III</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>PHYS 212—University Physics: Elec &amp; Mag</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TAM 211—Statics</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Elective in social sciences or humanities 3</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours</th>
<th>Second Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 ECE 110—Intro Elec &amp; Computer Eng</td>
<td></td>
</tr>
<tr>
<td>2 MATH 225—Introductory Math Theory</td>
<td></td>
</tr>
<tr>
<td>3 MATH 231—Calculus II</td>
<td></td>
</tr>
<tr>
<td>4 PHYS 211—University Physics: Mechanics</td>
<td></td>
</tr>
<tr>
<td>3-4 RHET 105—Principles of Composition or GE 101—Engineering Graphics &amp; Design 1</td>
<td></td>
</tr>
<tr>
<td>16-17</td>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours</th>
<th>Second Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 GE 330—OR Methods for Profit &amp; Value</td>
<td></td>
</tr>
<tr>
<td>3 MATH 285—Intro Differential Equations</td>
<td></td>
</tr>
<tr>
<td>2 PHYS 214—Univ Physics: Quantum Physics</td>
<td></td>
</tr>
<tr>
<td>3 TAM 212—Introductory Dynamics</td>
<td></td>
</tr>
<tr>
<td>3 TAM 251—Introductory Solid Mechanics</td>
<td></td>
</tr>
<tr>
<td>3 Elective in social sciences or humanities 3</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours</th>
<th>First Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ECE 211—Analogue Circuits &amp; Systems</td>
<td></td>
</tr>
<tr>
<td>3 GE 310—General Engineering Design</td>
<td></td>
</tr>
<tr>
<td>4 GE 320—Control Systems</td>
<td></td>
</tr>
<tr>
<td>3 Secondary field option elective 2</td>
<td></td>
</tr>
<tr>
<td>3 Elective in social sciences or humanities 3</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours</th>
<th>Second Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 GE 311—Engineering Design Analysis</td>
<td></td>
</tr>
<tr>
<td>1 GE 312—Instrumentation and Test Lab</td>
<td></td>
</tr>
<tr>
<td>3 GE 331—Analytical Methods for Uncertainty</td>
<td></td>
</tr>
<tr>
<td>0 GE 390—General Engineering Seminar</td>
<td></td>
</tr>
<tr>
<td>3 GE 424—State Space Design for Control</td>
<td></td>
</tr>
<tr>
<td>3 Secondary field option elective 3</td>
<td></td>
</tr>
<tr>
<td>3 Elective in social sciences or humanities 3</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours</th>
<th>First Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5 GE 400—Engineering Law 5 or 6</td>
<td></td>
</tr>
<tr>
<td>4 TAM 335—Introductory Fluid Mechanics</td>
<td></td>
</tr>
<tr>
<td>3 Design elective 2</td>
<td></td>
</tr>
<tr>
<td>3 Engineering science elective 2</td>
<td></td>
</tr>
<tr>
<td>3 Secondary field option elective 2</td>
<td></td>
</tr>
<tr>
<td>16-18</td>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours</th>
<th>Second Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-3 GE 494—Senior Engineering Project I and GE 495</td>
<td></td>
</tr>
<tr>
<td>4 GE 400—Engineering Law 5</td>
<td></td>
</tr>
<tr>
<td>3 Secondary field option elective 4</td>
<td></td>
</tr>
<tr>
<td>3 Elective in social sciences or humanities 3</td>
<td></td>
</tr>
<tr>
<td>6 Free electives</td>
<td></td>
</tr>
<tr>
<td>17-15</td>
<td>Total</td>
</tr>
</tbody>
</table>

Figure 4.2: The suggested core curriculum for engineers at UIUC.²⁶

Another unique feature of the French system is that the school of engineering is entirely self-sufficient, meaning that students and faculty never have any need to enter any other building on campus.

![Figure 4.3: Map of campus with ENSIP in the center, represented by “B1”](image)

Although the engineering building (see B1 in Figure 4.3 above) is surrounded by the law, library science, literature, and sport science buildings, ENSIP students have no reason ever to traverse through those spaces. All the courses that would normally take American engineering students to other parts of campus—requiring them to interact with non-engineering students and faculty—are taught in-house in the French system: the ENSIP has its own humanities faculty, its own foreign language teachers, its own English department.

Within the nearly-autonomous engineering building, I was a nearly-autonomous instructional unit. Because I taught the most advanced first- and second-year English classes at the ENSIP, I was granted nearly full creative control with my syllabus. However, my instinctive use of learning outcomes familiar to me from my years teaching Freshman Composition and Professional Writing in the U.S. made some ENSIP colleagues and students noticeably
uncomfortable. For instance, in my course rationale for the first-year ENSIP students (see Figure 4.4), I expressed my intent to ‘get them outside their comfort zones.’

![1ST YEAR ESIP ENGLISH: INNOVATION & IMAGINATION](image)

1ST YEAR ESIP ENGLISH: INNOVATION & IMAGINATION

INSTRUCTOR: Rebecca Bilbro

COURSE RATIONALE: This course will be an exploration of the complex relationship between innovation (=Engineering?) and imagination (=Science Fiction?). Our goal will be to strengthen your English speaking, listening, thinking, and writing skills by pushing you outside of your “comfort zone”. We will also do some (minimal) preparation for the TOEIC exam, which you take in your second year.

WRITTEN HOMEWORK:
You will compose five written responses about your own perspective on and reactions to a given topic. Each response should be approximately 500 words long.

*Figure 4.4: Freshman Comp language in my syllabus for the first-year English course at ENSIP.*

Though I had merely imported the phrase from an old Freshman Comp class, my language had the opposite of the intended effect: making students leery rather than eager. On the other hand, my “crazy” approach was perceived by others as refreshing; when I presented my second-year students with assignments adapted from a special topics course I’d taught for the Professional Writing program at my U.S. institution (see Figure 4.5), I found them rather more willing to accept it than my American students had been.

For both the first-year and second-year students, class began on most days with a short in-class reading, audio excerpt, or film clip. After reading, listening, or watching, we would work together to interpret some of the unfamiliar idiomatic phrases and then do a kind of collective explication de texte. Next, we would discuss how these clips complicated and extended ideas from the out-of-class responses I had the students compose before each class session (e.g. “Going Green,” shown in Figure 4.5 below).
“Going Green”—Due November 12
More and more companies are “going green.” Are we moving towards a more environmentally conscious business world or is “going green” just strategic advertising?

Figure 4.5: Professional Writing homework topic wildly popular with 2nd year ENSIP students.

In the U.S., such out-of-class assignments would have held students accountable for completing out-of-class readings and encouraged them to compose their thoughts before in-class discussion. At the ENSIP, where I did not require out-of-class reading, these assignments became creative, low-stakes ways for students to experiment with using written English to express their opinions and recount stories. In the last twenty minutes of class, we’d segue from the discussion of their ideas to a reflection on a larger communicational issue related to their next assignment or final project.

Thus, most of the student writing I saw was commissioned by me for class: weekly out-of-class writing assignments, PowerPoint presentations, outlines, drafts, in-class notes, and emails. Of their engineering writing, I glimpsed only bits and pieces: a student dropped a sheet of notes from her Water Treatment class, another student accidentally emailed me a PowerPoint presentation for Mechanics class, a group of five students sometimes stayed after class to work on problem sets for Complex Analysis. Later, as we grew more familiar with each other, I was allowed access to more of their “non-disciplinary” writings: drafts of resumes and cover letters for summer internships in Anglophone countries, personal emails, diligently maintained Facebook pages, and a copy of the student-run newspaper, The Agitator (Figure 4.6).
Figure 4.6: Copy of the ENSIP student-run newspaper (1st edition), for which I had to pay.

Textual Artifacts

Beyond those introduced by me, the multilingual complexity of the ENSIP was further mediated by another thread in the mangle, the Test of English for International Communication (TOEIC). After three years of classes prépas, followed by three years at the ENSIP students must pass a test of English proficiency in order to officially graduate, most commonly the Test of English for International Communication (TOEIC), which is the cheapest and easiest to administer and grade. An engineer who has been successful in all of his or her discipline-specific courses, but who is unable to pass this test with a score of at least 75% will not receive
his or her degree in Engineering. At schools that wish to distinguish themselves, such as the *École Polytechnique* in Paris, this cut-off percentage can be much higher. All students at the *ENSIP* are required to pass the TOIEC in order to officially graduate. My students, the school administrators, and my fellow English teachers all agreed on the supreme importance of preparing for the TOEIC; as one colleague explained,

> You'll probably want to do one or two mock TOEICs with your first-years so they can try it, but the school doesn't give the official TOEIC until the end of first semester for the second-year students. This official test is the one that “counts,” and if a student doesn't get a 750 on that one, he/she has three more semesters before graduation to keep taking it at his/her own expense. No 750 on the TOEIC means no engineering diploma. That’s national law for all engineering schools.

In other words, an *ENSIP* student who has been successful in all discipline-specific courses, but who is unable to pass this test with a score of at least 75% will not receive his or her degree in Engineering.

A striking implication of the French government’s testing mandate is that in order to be a successful engineer, one must be proficient in English, a foreign language. French engineering schools compete to demonstrate their superiority by raising the English-language testing cut-off scores. Such variations in the way English literacy is valued and institutionalized at different schools brings to mind Winsor’s (1996) observation, that “the activity system known as engineering is itself always changing, meaning that what counts as expertise changes too” (p. 106). Moreover, what counts as expertise in engineering also varies greatly between cultural contexts: though fluency in English is also an implicit expectation of engineers at my US institution, multilingualism and multiliteracy have no place in the curriculum. There is a
dramatic difference between the disciplinary value system of engineering in France and the US, and these kinds of differences have co-evolved with numerous other laminated practices and beliefs.

The national mandate has also made disciplinary writing much more invisible to members of the ENSIP than to engineering students at my US institution. Administrators at the ENSIP chose to purchase a subscription to the TOEIC, not because it is the nationally–mandated test, but because it is the most economical choice. Unlike the TOEFL exam, the TOEIC does not have a written component, meaning it does not necessitate the essay-raters that make testing and grading slow and expensive. The TOEIC includes only two sections, English reading and listening comprehension, meaning that students’ exam sheets can be assessed with a simple Scantron machine. However, because the TOEIC does not require students to write, the demand for explicit discussions of writing at the ENSIP has diminished, and the perceived need for discussions of grammar rules has increased. Writing has, in turn, become an absent presence, as evidenced by a colleague’s flip response to an email exchange about teaching writing as a way of learning: “Students usually admit,” she wrote, “that writing homework is necessary, (though not always pleasurable).”

During my time in the small English department housed within ENSIP, I saw that, in addition to the TOEIC, my colleagues were preoccupied with another manifestation of mangled disciplinarity. Making English part of the national engineering curriculum, they explained, has meant that lower-income students and non-native speakers of French are less likely to survive engineering school. They were worried that the academic tracking procedures at the ENSIP were preventing weaker students from learning from their stronger peers. It came as a bit of a shock to me to discover that tracking was so ubiquitous and overt in France, because in the
American context, tracking is usually considered unethical. Of course, American tracking still exists, but now in limited or disguised ways. But while I encountered only a very few students of color in my advanced English courses, my colleague, who taught the weakest English students, worked with nearly one hundred percent of the minority students at the ENSIP.

Tracking was at work on both institutional levels (e.g. segregating students into different classes) and in quotidian contexts, such as in our grading practices. The ENSIP administrators encouraged us to grade harshly, and I was told to grade even more harshly than I might with American students because I was working with the most advanced group. A colleague explained,

> Grading is on a 20-point scale. Students need an average of 12/20 to be able to graduate. Basically, an A = 15-18, a B = 12-14, a C = 9-11. We definitely give 7s or 8s as semester grades when students have been absent 50% of the time and/or haven't turned in homework. The difficulty of the French educational system and the high standards placed on the worth of the intellectual tend to mean that NO one ever gets a 20 out of 20.

I was fascinated by this notion of “the worth of the intellectual,” which clearly had been interpreted in many different ways by my predecessors in the teaching exchange program: As I was cleaning out a closet one afternoon, I discovered a stack of Thanksgiving-themed crossword puzzles buried under TOEIC test guides, which were clearly aimed at language learners still in primary school. I couldn’t help but think that such activities, which had likely been introduced into the mangle by an American teaching assistant, must have seemed very odd to these elite engineers-in-training.
Political Engineering

In part because of this influence of American teaching assistants, the mangle of practice at ENSIP was intricately interwoven with texts that one might not expect to find in such a context. One of the most popular texts circulating at the school during my time there was a photocopied ballot from Florida (Figure 4.7).

![Figure 4.7: U.S. presidential ballot—a hot topic at ENSIP in the 2008-2009 academic year.](image)

French citizens seemed, on the whole, to be very invested in the American presidential elections during the 2008-2009 academic year. Barack Obama had become a celebrity, and his face was plastered on every surface in every public space of every French town I visited. At ENSIP, students frequently asked me if I was planning to vote in the election, if it were possible for me to vote while living in France, and if so, whether I intended to vote for John McCain or Monsieur Obama. The Floridian ballot was particularly interesting to the students, many of whom were familiar with the U.S. state that had, for poorly understood reasons, played a major role in a previous presidential election with less than optimal results. I received many questions
about the roles of Florida, the Electoral College, and individual voters in the American electoral process.

Given the students’ interest in the elections, I was very surprised at their responses, a few months later, as university students and staff across France went on strike in protest of proposed reforms in higher education. For two weeks, students from the local colleges of law, business, and letters were joining in with the strikers, not attending classes, and sometimes shutting down whole buildings on campus. During that time, I had perfect attendance—certainly not the norm in my ENSIP courses—so I asked my students to help me understand the disparity. Their response was that none of them ever went on strike and that engineers were “not very political” or “too busy for politics.” And though it was true that no ENSIP students or faculty went on strike during my year there, it was difficult to reconcile the statement that “engineers are not political” with the students’ clear interest in Obama, the business of “going green,” and The Agitator (the student-made newspaper, Figure 4.8), which covered many highly politicized topics such as golden parachutes, the financial crisis, community supported agriculture (“les AMAPs”), feminism, and French President Nicolas Sarkozy’s controversial new digital surveillance program (“EDVIGE”).

![Figure 4.8: Excerpt of the front page of The Agitator, enumerating its (highly political) contents](image)
Even the faculty at ENSIP seemed very interested in politics. One particularly odd political text emerged from the mangle when one of the engineering faculty members led an English-language debate for my class at the end of the year (Figure 4.9).

With the goal of providing students a chance to use English to write from within their discipline, I asked the professor—himself enthusiastic to practice his English skills—to select an engineering-related topic that students could write about and discuss in a jointly-facilitated debate led by him and myself. The topic he selected—the rise in anti-Darwinian sentiment and intelligent design-laced curricula in the United States—was surprising, deviating from the location I was expecting both in terms conceptual space and literal space. But he was clearly better attuned than I; the students were incredibly enthusiastic to discuss intelligent design and creationism in the context of the American school system.
Although France does have a small population of anti-evolutionist Christians, the majority of French citizens are either secular humanist or Catholic. And, with the Pope’s statement, in 1996, that evolution is backed by scientific evidence and is not merely a theory, French Catholics and secularists are generally in agreement that evolution occurs, as Darwin argued, by natural selection, and not by the hand of God. However, creationist ideology in France is quickly changing with the increase in the population of French Muslims, many of whom are resistant to evolution. Thus, although the debate in my class at the ENSIP was ostensibly about the American school system, my Muslim students took a distinctly different position from their classmates. In this case, the distance of the location seemed to create a safe space for students with different religious and political beliefs to disagree about the value of equal instruction time for both creationist and Darwinian curricula.

*In and Out of School*

Whether or not my students and fellow faculty viewed writing as an afterthought, it was clear from what I saw, both at school and in town, that everyone around me was constantly writing. I knew this because in our little town near the Loire Valley, *papeteries* (paper and stationery stores) were almost as common as *pâtisseries*. The French put enormous weight on paper-based discourse and handwritten documents in both personal and professional contexts. To open a bank account at the local Société Générale, to file for a residency permit, or to request a work visa, to apply for or accept a job—all correspondence is done on paper, by hand, and usually in triplicate. After returning to the United States, I continued to get correspondence from our rental agency for several months (Figure 4.12).
Figures 4.10 and 4.11: Local papeteries

Figure 4.12: Follow-up correspondence important enough to merit international postage.

Digital copies and internet communication are considered unreliable or purely supplementary. In fact, I had arrived three weeks late to my job at the ENSIP because of a problem with my paperasse (the derogatory term for “paperwork”). The documentation approving my work visa was misfiled at the head labor office in France and then mistakenly sent to the wrong American consulate. Though all offices had been in correspondence by email for
the duration of my application process, all were aware of the legitimacy of my claim to French employment, and all supported the approbation, digital acknowledgements and signatures just could not substitute for the real thing.

These kinds of non-canonic, non-disciplinary writings may seem tangential, as Dias et al. (1999) famously hypothesize that practices of grading and ranking preclude transfer from school contexts to “real world” contexts, and vice versa. And yet, as Thaiss and Zawacki (2006) have argued, school writing is not literally “worlds apart” from writing-in-the-world, and these contexts both inform and scaffold each other, particularly in relationship to learned behaviors and cognitive processes. Furthermore, as Prior (2004) explains, investigating literate practices “also means tracing the inner thoughts, perceptions, feelings, and motives of the writer(s) as well as tracing exchanges between people, exchanges in which the content and purposes of a text may be imagined and planned” (p. 167). Literate activity, as Prior finds, can involve mundane tasks and behaviors like “drinking coffee, eating snacks, smoking, listening to music” (p. 171). For these reasons, it became increasingly important for me to seek out rhizomatic links from ENSIP students’ school-writing to other practices like standardized test-taking, Facebook-updating, stationery-purchasing, letter-writing, emailing, hand-drafting, and document-signing.

I also began to consider how sociohistoric tensions between traditional pen-and-paper writing practices and requirements of the digital age were manifesting in disciplinary knowledge production at the ENSIP. Our “tech support” consisted of one single employee for a school of more than 300 students and about forty classrooms and offices, a painfully shy man who came to campus two or three times a week and frequently did not respond to electronic mail. As colleagues wryly suggested, the best way to catch him was to lay in wait around the corner from his office door, ready to jump out should he appear. The English teachers had apparently
developed and refined this strategy with a dedication that had much to do with their newly-installed technologically-enhanced classrooms. Though these “smart rooms” looked very nice in the school’s advertising leaflets and had been extremely costly, they malfunctioned on a daily basis, subject to problems from computer viruses, to disconnected projectors, to faulty electrical outlets. Thus, when teaching with technology was not an option, we resorted to paper handouts, which should have been optimal, given the preference for paper in French society. But, paradoxically, there was only one employee at the ENSIP whose right it was to touch the copy machine, Madame la photocopyiste, who also had to spend half of each day supplementing the janitorial service, and was thus frequently unavailable. Perhaps this is what Pickering (1995) has in mind when he writes that we must “let the tradition define the terrain” (p. 179).

**Indigenous Mangles**

Even before arriving to my post in France, I had a researcher’s understanding that the journey would require both methodological and pedagogical work on my part. Unfortunately, due to another strand of the mangle, which makes international, cross-institutional research almost prohibitively difficult—the dreaded Institutional Review Board (IRB)—I was poorly positioned to collect data in any official capacity. Another key challenge of this kind of work, as international researchers of writing (e.g. Donahue, Brereton, Gannett, Thaiss, and Lillis) have explained, is that college-level writing instruction does not exist in the same incarnations in the university systems of all countries. Moreover, much writing research is never written up in or translated into English; in my case, though I had been vaguely aware of an on-going body of French research on writing instruction (e.g. Donahue, 2008), I was not sufficiently fluent to apply it to my pedagogy at the ENSIP. This problem of research lost in translation is, I suppose,
one necessary evil of the mangle. However, the problem of research that is mutually incomprehensible for disciplinary reasons is somewhat more serious.

The closest French analogue for what we in the United States variously call “Rhetoric and Composition” and “Writing Studies” is, as Donahue (2009a) explains, la didactique de l’écrit, or French didactics research. But such disciplinary spaces are new and small, and as Donahue elaborates, “French scholars have only recently begun to focus on theorizing writing across the disciplines” (p. 425). Moreover, large spaces exist—both in France and the United States—for “empirical” research, which creates a disciplinary milieu often hostile to the collection of qualitative data about textual production and literate experience. Such large disciplinary pockets often rely on what Pickering calls the representational idiom, which sees research as “an activity that seeks to represent nature or how the world really is” (p. 5). Empiricists presume that their research concerns the acquisition of facts that allow for the production of comprehensive maps of reality. By reinforcing such conceits, Pickering suggests, the representation idiom prevents scientists from capturing human and material agency, instead divorcing their work from everyday lived experience and rendering data that is ultimately unrepresentative of our mangled worldly existence.

Donahue (2008; 2009a; 2009b) has recently helped to identify two ways in which the representational idiom is emerging in international writing research: firstly, in the proliferation of “untranslatable” research, or work that does not make sense outside its disciplinary and cultural context, and secondly, in absent, distant, or dis-integrated descriptions of the writing context. The phenomenon of untranslatable research is less a problem of linguistic translation and more a problem of cross-cultural, cross-institutional, and cross-disciplinary communication. Foreign research is made more foreign when social, institutional, and disciplinary forces (e.g.
cultural mores, IRB committees, funding agencies, etc.) push researchers to be more empirical, to represent the facts instead of the faces. The second problem—the problem of context—is, I think, mostly a problem of genre. The representational idiom asks the researcher to report on Context, but to insinuate objectivity by doing so only in a section separate and often remote from Results. This practice is common both within and outside of the sciences, as Bazerman and Paradis (1988) explain, “[in English Studies] textual analysis typically isolates texts from their social and intentional origins…we are thus conditioned to associate the text and all its attendant acts with academic remove” (p. 3). The disciplinary and cultural contexts are, thus, invisibly or only distantly connected to writing-in-practice and we fail to connect texts with lived experiences.

Pickering’s performative idiom might serve as a remedy to Donahue’s concerns. His performative turn, in asking us not to “represent reality,” but to research ways of “being in the world”—to be ontologists instead of epistemologists—might enable international researchers to see language, culture, and discipline in terms of the co-production of literate practice, rather than as distant contexts of writing. It is possible that such an approach would solve both aforementioned complications of the representational idiom, by integrating contextualizations that make research more comprehensible beyond our native language, country, and disciplinary context and by presenting a more dialogic view of the relationship between contexts and writing practices.

But my sense is that the scholarship has already begun to move in this direction, since the ideological and ontological problems of international scholarship are contiguous with the challenges faced by all researchers of writing. This, at least, has been my conclusion after a year spent teaching writing in France. My exploration of the quirks of the French mangle has made
my native mangle appear infinitely more complex. Now that I’m back to teaching and researching writing in my home context, I am more keenly aware of the need to think complexly about how practices are woven into larger mangles and how “knowledge is threaded through the…field” (Pickering, 1995, p. 7). I am more inclusive of my students and participants’ layered subjectivities, and I think more about how disciplinary writing engages non-canonic practices. When I look at textual artifacts, I try to be more attentive to what Prior and Shipka (2003) call “the dispersed, fluid chains of places, times, people, and artifacts that come to be tied together in trajectories of literate action along with the ways multiple activity footings are held and managed” (p. 180). In witnessing the mutability of institutional practice across disciplines and cultures, I have begun to understand the extent to which all institutions are exotic, mangled spaces.

Cedric is in the unique position of being able to speak to the terrains and traditions of engineering in both France and the United States. A French citizen living and teaching at UIUC on an H1-B visa, Cedric grew up in France and went through the French school system, including classes prépas and grande école. He came to the United States about ten years ago in order to get his PhD in theoretical and applied mechanics. When I asked why not a doctorate in engineering, Cedric responded that in France, engineering does not hold the allure it does in the United States: “In France, engineers are failed mathematicians.” In fact, even the American engineering schools held in highest regard by Americans are not seen in the same way by the French:

My school [in France] had exchange students from other countries, from other engineering schools in Milan, Montreal, MIT. Interestingly enough, we had two or three MIT exchange students every year, and invariably, they were the students
who failed everything, and I mean everything. They were even allowed to take their exams in English, and still [they failed]. Every year I was there, every student from MIT failed every single course.

Cedric’s unique experience puts the “real world” vs. “school world” engineering distinction into a whole new light. In the French educational hierarchy, theoretical, “pure” disciplines take precedence over applied disciplines. Pure mathematicians are positioned at the very top, and as Cedric explained, the surest path into influential careers in French government and business is a bachelor’s degree in math (not an MBA or a JD, as is often the case in the U.S.). Engineers, he explained, are rarely seen as intellectuals, and more often as technicians, calling to mind the depiction in Kipling’s “Sons of Martha” poem. Thus, not only does France privilege pure theory over applied science, its educational system has made the path to industrial engineering much more straightforward than the path to academic engineering.

Engineering schools in France do not aim at creating researchers, they really create engineers for industry. In high school, if you want to stay in science, social pressure would say go to classes prépas instead of university, go to engineering school, and then you will never do research, but if you want it, then maybe you go back to university for graduate studies [to do academic engineering].

After saying this, Cedric paused, and wondered aloud, “But isn’t that pretty much the same thing here?” It’s an interesting question, and the answer, as we saw in Chapter Three, depends a lot on which teachers you talk to.

Another discussion about the uniqueness of the French and American engineering mangles emerged when we talked about the TOEIC exam I had had to administer at the ENSIP.
Cedric remembered having to take the TOEFL exam at his *grande école*, and I asked him whether or not, in retrospect, he felt it was really important for all French engineers to be proficient in English. He responded that the English education was perhaps not the goal in and of itself, but a political choice, a way of preempting France’s embarrassment on the international stage.

I think that the idea in France is that people are pretty bad at speaking foreign languages. I think that’s a German joke, actually, “how do you call someone who speaks three languages? Trilingual. And two languages? Bilingual. And only one language? French!” That’s the idea of us in Europe, that we’re the ones who don’t know how to speak any other languages. I don’t want to propagate hearsay. But I do have the experience of going to professional conferences with French people from the top schools, with the best possible training in engineering and science, and giving talks that would just irk me to no end. That’s the thing that is hard to understand. You obviously got the best training in your education in France and still your English is pathetic to the point that I barely can understand the math you are talking about.

It was very strange to hear such a different characterization emerging in our discussion; rather than the stereotype of the pale, brainy, effete, antisocial engineer in the U.S., the stereotypical French engineer is a coarse, blustering clod who couldn’t cut it as a mathematician. Cedric is quick to call the stereotype silly and untrue, but in his eagerness to differentiate himself as an engineer who enjoys reading, film, theatre, and language, he underscores his sensitivity to the misrepresentation.
Cedric is reluctant to draw fine distinctions between engineering in France and the United States. When we spoke about the spaces that engineering students navigate on a daily basis at UIUC, he alluded to an *ad hoc* model of enculturation much like Crane’s (1972) “invisible colleges.” While I suggested that the space of *ENSIP*, which segregated the engineering students and faculty from other disciplines, was a unique feature of engineering education in France, Cedric countered that this is perhaps not so different from the American system; “Do [the engineers] really have that many friends outside their classes? Do they really spend that much time outside the engineering campus?” I reminded him that engineers at UIUC must traverse Green Street (the border which demarcates the engineering campus from the arts, humanities, and science buildings), at least on occasion in order to satisfy the general education requirements in writing, communication, and culture. But Cedric remained dubious, suggesting that it was possible to travel “south of Green” without really leaving the engineering campus. Over time even certain writing and humanities courses, he suggests, “have become earmarked as being ‘for engineers only’,” making American engineering colleges almost as autonomous as French ones.

Here, in Cedric’s picture of the discipline of engineering—as something that moves *with a person* as he or she moves through space—we can see how Pickering’s metaphor begins to fail. In Pickering’s view, the practice of discipline is like the mangle: a laundry press with a hand-turned crank that removes the excess water from freshly washed clothing. For Pickering, the image of the shirts and pants and linens kaleidoscopically twisted up and unpredictably entangled captures the complexity of science (or engineering) in the making. However, after shirts and pants and linens are put through a mangle, they are dried and starched and ironed. In
the end, they hang up in a closet, on separate hooks or perfectly folded, orderly, distinguishable, and no longer entwined.

The next chapter considers just how inextricable the process of enculturation really is, seeking a better way than Pickering’s mangle for understanding the complex disciplinary diffusions and activities, which are not strictly bounded or divisible in the way our representations would make it seem. As we can see in the case of the ENSIP, disciplinarity is not just something that happens in a laboratory, an office, or a library. Moreover, we are apt to imagine the disciplined activities of scientists and engineers as the most strictly bounded of all. If Klein (1993) has shown that scholarship is messy, or Pickering (1995) has shown how complexly laminated science can be, there is a remaining sense that scientific and technological work is stable, regulated, and distinct from other disciplines, somehow immune to the ocean-like currents that pull on everyone else. In the interest of complicating this image of the impassive, nonaligned nature of disciplinary practice in engineering, we will in the next chapter return state-side for an up-close and personal look at some of the people currently navigating these rough waters.
Chapter Five: Home Discipline

All that you touch
You Change.
All that you Change
Changes you.
The only lasting truth
Is Change.
God is Change.

-Octavia Butler\textsuperscript{27}

Though the above bit of verse from the late Octavia Butler’s novel, \textit{Parable of the Sower}, is the crux of the protagonist’s post-apocalyptic religion, it also captures the reciprocal relationship between individuals and their environments in a way that many models and studies of enculturation have failed to do. In Butler’s book, a young black woman named Lauren Olamina has rewritten the Christian Bible as a road map for surviving the end—and rebirth—of the world. Through Lauren, Butler articulates the organic reciprocality of self and society, guided by a single rule: that evolution is not only imperative, but inevitable. In this chapter, I would like to articulate a similar reciprocality as it concerns processes of enculturation in the College of Engineering. Informed by Butler’s speculative fiction, as well as critical race theory and feminist theory, I use the oxymoronic commonplace “home discipline,” a phrase employed equally fluidly and unselfconsciously by scientists and humanists and a particularly convenient way to talk about the enculturation as an act of simultaneous self-branding and territory-marking, while also raising questions about the (human) bodies within (disciplinary) bodies.

\textsuperscript{27}“Earthseed: The Books of the Living” from Butler’s \textit{Parable of the Sower}.
We have come to conceptualize disciplinary enculturation mostly in terms of how humans (and sometimes non-humans) assimilate into new systems of activity. Models of enculturation emphasize linear movement outwards (“distributed cognition”), upwards (“scaffolding”), or inwards (“legitimate peripheral participation”). As Mead (1936) writes, “mental process...has evolved in the social process of which it is a part. And it belongs to the different organisms that lie inside of this larger social process” (p. 381). Top-down representations like Mead’s help us to visualize how “the social” functions—how values, bodies of knowledge, histories, practices, and languages trickle down into individuals—but they do not explain where society comes from. More recent models have become more comprehensive (Giddens, 1984; Berkenkotter, Huckin, & Ackerman, 1991; Berkenkotter & Huckin, 1994), balancing structure with agency, accounting for human and non-human constitution of activity systems. As they employ the values, bodies of knowledge, histories, practices, and languages, the members reify the system. Thanks to these models, societies, universities, and disciplines no longer appear to us as stable monoliths, but as slowly and always in motion.

However, only Giddens’ theory of structuration seems to succeed in representing the possibility of the deliberate or active constitution of society. For, if humans (and non humans) can only passively constitute their societies, we cannot account for innovation (“All that you touch/You Change.”). And when we acknowledge the innovation-imperative and the disruptive power of change, how can we account for the persistence of enculturation and disciplinarity (“The only lasting truth/Is Change.”)? What can last if all is change? Giddens’ model, though perhaps the most robust and inclusive of all, suffers from what David Wilson called a “tyranny of taxonomy.” Wilson’s (1995) critique of Giddens indexes the simultaneous strength and weakness of models that help us to conceptualize activity in the most abstract of ways:
Structured thus simultaneously elucidates and binds us, gives us clarification and ambiguity, which comes when any theory of social life is anchored in a singular vision...What becomes important in each case, however, is the specifics of the assumptions, the revealed insights, and the hidden dark spots that permit us to capture one specific glimpse of complex social life. (pp. 309-310)

What are some of these hidden dark spots in Giddens’ model? Like most disciplinary models, structuration theory tends to eschew the idiosyncrasies of human and non-human bodies. Some have managed to overcome the disembodying qualities of abstract models and taxonomies and retrieve isolated individuals within a discipline: Berkenkotter’s study of Davis and Cronin, Ackerman’s study of Nate, Latour’s study of Pasteur, Bazerman’s study of Edison. Nonetheless, raced, classed, gendered, and queered bodies are routinely absent from models (e.g. Latour’s “actant-rhizomes” and Engestrom’s “activity systems”) and thus, research on disciplinarity, even when the research concerns everyday lived experiences and histories of disciplined bodies. Those few scholars who have written embodied accounts of disciplined literate activity (Royster’s Traces of a Stream, Johnson’s Gender and Rhetoric Space in American Life, 1866-1910, Bauers’s Indecent Proposals, Richardson’s Fields of Play) have done so without the benefit of readily available disciplinary heuristics.

Swales’ (2004) account of research genre types does encourage an emic mapping between canonic and disciplinary practices (e.g. Engineering dissertations are written by Engineering students). Nonetheless, he admits that genre studies must “[leave] sufficient space for individuality and idiosyncracy, for the maverick, the iconoclast, the splinter group, even the cult around some academic guru” (2004, p. 18). Swales is, at least, willing to acknowledge the possibility that the experiences of unique individuals can articulate and even shape disciplinarity,
though he sees this as the exception, not the rule. Like many who have sought to find broad patterns in technical and scientific work (Biglan, 1973; Becher, 1989; Sokal, 1996), Swales sees technical and scientific genres as fundamentally more rigid, more disciplined than those of humanists and social scientists. Though not nearly as strong as Sokal and Bricmont’s (1998) claim that postmodern scholars (and, by halo effect, all humanists) are “intellectual impostures,” Swales’ belief in the rigidity of scientific and technical disciplines evidences an implicit and widespread skepticism of disciplines that value qualitative, affective ways of collecting, analyzing, and disseminating data.

For example, this skepticism of the qualitative approaches of critical race theory to legal studies is what prompted Judge Richard Posner (1997), in his glowing review of *Beyond All Reason*, to write that authors Daniel Farber and Suzanna Sherry had isolated “what is most arresting about critical race theory” (p. 42). For Posner, as well as Farber and Sherry, the problem with critical race theory is that it is irrational—doesn’t even pretend to be rational—which in turn reflects poorly on the abilities of scholars of color to think and do “proper” research.

Rather than marshal logical arguments and empirical data, critical race theorists tell stories - fictional, science-fictional, quasi-fictional, autobiographical, anecdotal - designed to expose the pervasive and debilitating racism of America today. By repudiating reasoned argumentation, the storytellers reinforce stereotypes about the intellectual capacities of nonwhites. (p. 42)

But Posner’s premise is flawed; as Gould (1981) tells us, the belief that humans can be fully rational is in itself irrational. What Posner objects to is not the irrationality of critical race theory, but to their disciplinary practices, which he perceives to be an intrusion on his “home
discipline” of legal studies. And yet, it is equally irrational to suggest that some of us only tell stories while others only tell facts.

In fact, during numerous interviews across the engineering campus at my institution, I have encountered many storytellers. Like critical race theorists and everyone else, engineers talk about their disciplinary experiences with storytelling techniques—analogy, allusion, anecdote, hyperbole, metonymy, suspense, drama—to give illustrative, necessarily subjective accounts of the inner workings of their fields. What I have found particularly interesting in these stories (my reason, in fact, for using the term “home discipline”) is how frequently storytellers enunciate relationships between discipline and ethnicity, nationality, sexual orientation, socioeconomic status, religious faith, political beliefs, and human bodies (skin color, sex).

In this chapter, I provide evidence that engineers’ accounts of their field routinely engage issues of race, class, gender, and sexuality. I believe these personal stories are as much an index of the disciplinarity of engineering as they are of the identities of individuals. Biographical, idiosyncratic experiences are externalized through discipline, and as individuals are composed by their disciplines, so too are they composing.

*Emily*

The first thing I noticed about Emily was the free and easy way she talked about her own literate experiences at work. Her understanding of writing was refreshingly practical and organic to engineering.28 She would say with perfect confidence and nonchalance things like:

---

28 As discussed in Chapter 3, many engineering faculty participants are proponents of humanist writing handbooks, encouraging and even requiring their students to use them. My treatment primarily concerns the uptake of humanities and social science texts in engineering contexts, considering the extent to which such uptakes trouble traditional models of disciplinarity.
The code development field defines ‘good’ writing as writing that communicates findings and suggests solutions to those involved in the technical development. ‘Good’ writing does not have to exhibit perfect grammar, especially when the technical minds involved did not learn English as a first language.

An alum of Electrical and Computer Engineering (ECE), she is now a successful code developer in a large metropolis. Emily’s ease of writing in the workplace extended fluidly to her accounts of engineering at UIUC, where racial identity and sex emerged as key themes; she told the story of her enculturation in terms of her raced, gendered body.

When she arrived at college, Emily felt out of place, lost in a sea of people, many of them white, but she quickly fell in with a group of Hispanic engineering students who scaffolded her social integration into UIUC, her academic success in her department, and her professionalization into the world of engineering beyond UIUC:

One of the most influencing parts that guided me on the path to becoming an engineer was the mentorship I received from upperclassmen during my first months on campus. Members of the Society of Hispanic Professional Engineers reached out to incoming engineering freshman students and acted as mentors to me throughout my undergraduate years. Whenever I had questions about what classes to take or needed advice on the books to buy or resources to use to study, someone who had already excelled in that area of the curriculum volunteered advice I could trust.

It is particularly interesting how Emily attributes many instrumental features of her enculturation into engineering to the Society of Hispanic Professional Engineers (SHPE or “shippy”).
In no time at all, Emily found herself in a series of powerful leadership positions within SHPE: Freshman President of the Freshmen Roundtable, Publicity Chair, Fundraising Chair. Emily credited these leadership positions as her introduction to writing and communicating for college and the work world; “Many of these roles,” she wrote “required putting together PowerPoint presentations, flyers, and letters to corporations.” In fact, Emily expressed her sense that she had learned as much about writing like an engineer during these publicity and outreach activities as in her coursework.

With her growing sense of power, Emily began to import components of her SHPE activities and practices into her department, ECE: attending conferences, workshops, banquets, and engineering challenges. She even began encouraging non-Hispanic students to join her in these activities.

*Figure 5.1:* SHPE’s facebook page articulates the organization’s mission statement.
She recalled SHPE’s mission (visible in Figure 5.1: “to return the support we are continuously provided”) saying, “Their selflessness in reaching out to me when I had nothing to offer them in return gave me a sense of obligation and an eagerness to help younger generations of students as they began their quest to become an engineer.” Explaining her internalization of SHPE’s mission, Emily echoed a strong personal desire to use her communicative prowess to give back to her community—meaning both SHPE and later, an association of female ECE students. As she became more concerned with the group of women, she began to focus her efforts on promoting women in engineering, eventually assuming the role of Outreach Chair for Women in Electrical and Computer Engineering (WECE);

As a part of my WECE Outreach efforts, I encouraged underclassmen to volunteer as coaches to an after school LEGO Robotics program at the all-girls Campus Middle School which culminated in the 10 girl team winning the Judge’s Award for team strength displayed in all aspects of the competition.

Most striking in Emily’s story is how stewardship, which ultimately extends beyond the college context, always leads back to her development as a high-achieving engineering student and a strong communicator and writer:

While participating in these extra-curricular activities I found students with whom I could study for my classes and whom I could tutor in classes I had already taken. I continue to keep in touch with my friends still on campus through email, gchat, and phone to offer advice on interviewing and class selection.

Unfortunately, Emily’s accounts of her growing value and communicative capital within her department—via her involvement with the SHPE and WECE communities—are not
necessarily the norm. Carol Livingstone, the Associate Provost and Director of the Division of Management Information, has been collecting enrollment data at UIUC for nearly two decades. In the last ten years, enrollment percentages of women in Emily’s department have decreased (from 13% of all ECE students in 2000 to 11% in 2010), but since Hispanic enrollment has always been consistently low, the drop in that demographic (from 5.5% of all ECE students in 2000 to 3.7% in 2010) feels more dramatic. Graduation rates of women and minorities in ECE are so low that Carol’s office has made the decision to suppress the data, fearing that reporting it would amount to identifying successes and failures of individual students. Other researchers at UIUC (see Larson, Cordova-Wentling, Loui, & Korte 2009) are struggling to determine why, when we do succeed in recruiting women and minorities into engineering, we fail to retain them. Much of this work has also turned toward interviews and case studies as the most promising source of data on the lived experiences of these students.

**Civil(?) Engineering**

I met with Ezell when he was a senior in Civil Engineering, just getting ready to graduate. When we met the first time, I recognized him instantly as one of the “regulars” at the school gym: tall and athletic with dark brown skin and a playful demeanor. Ezell, a native of North Carolina, hadn’t even known about UIUC until the Big Ten men’s basketball tournament of 2005, the same year he started applying to colleges. UIUC’s success on the court and in the engineering school rankings drew his attention away from the other Midwestern university he had originally planned on attending.

Ezell’s well-roundedness is evident in the wide breadth of topics he covered as he introduced himself to me: his family of high achievers, his fraternity (which he quickly
distinguished as an academic rather than a social fraternity), his reasons for transferring from the Electrical and Computer Engineering department to Civil Engineering (he preferred lab work to purely theoretical classes). And yet, these many trains of thought intersected in the unfolding story of his experiences as a black student on campus and the feelings about which he is clearly conflicted.

As of Spring 2011, UIUC is approximately 5% black. Of our 40,239 students, 2,047 (5.09%) identify themselves as African American and 2,272 (5.65%) identify as either African American or multiracial with African American ancestry. Of the 8,123 students in the College of Engineering, only 110 (1.35%) are African American. Though disappointing, these statistics cannot be said to shocking, as they are well known by anyone who has spent any significant amount of time on campus. Ezell’s experience, however, captures the ambiguity of actually living those statistics. In one moment, he talked about how strange it felt to be one of the few African Americans in the College of Engineering, not to mention the campus as a whole. A moment later, he spoke with some pride about being chosen to represent a “diverse student” in a recruitment video for the College of Engineering:

I did this video over the summer. I just had a script that they sent me to present to the camera. I believe they had a different person from each ethnic or racial background to make up the video segment. So it’s pretty much just a way to get the College of Engineering to be more diverse, and to attract more students in the different diversity programs. I haven’t seen the video yet myself, but we’ll see how it works out.

And yet, from the faint tone of skepticism in his last sentence, we see that Ezell’s pleasure at being singled out for recognition amongst more than 8,000 peers in the College of Engineering is
mitigated by an understanding that this recognition might not have much to do with his academic and extracurricular successes.

Like Emily, Ezell has access to a local chapter of a well-established racially-aligned organization on campus, in his case, the National Society for Black Engineers (NSBE or “nezby”). But when I probed his engagement in the club, imagining that perhaps he, like Emily, would attribute his success and mentorship to NSBE, he explained with some chagrin that he had never really become involved in the club because “it didn’t feel right for me.” I asked Ezell to explain what he meant, and he told me that before he had come to UIUC, a mentor had advised him “not to hang out with the other black kids.” As I silently wondered why this might be, and how strikingly different his experiences were from Emily’s, Ezell intuitively answered my unasked question:

So I’ve been here four years, and I love it. But the recent acts of violence, the mass emails we get about police action on campus have put a damper on things. It’s not that I’m getting the evil eye when I walk around campus, because a lot of people know me and they know who I am, but I can tell you that since freshman year, since we started receiving those emails back in freshman year, my friends and I are on instant messenger or on the phone, saying “did you see that newest message?” and we’re like “please don’t let it, please don’t let it, please don’t let it be a black man!”

The messages to which Ezell refers are called Crime-Alerts (see Figure 5.2). UIUC’s Chief of Police regularly sends out these alerts to everyone on campus, including students, faculty, staff, and administrators. However, there has been some controversy on campus about these alerts for several reasons.
First, crime statistics on campus remain fairly consistent, and while the frequency of these alerts do not seem to have lessened crime, they seem to have had a large impact on campus perceptions of crime and violence. Moreover, alerts are not issued for all crimes (generally only for assaults and violent robberies) and can only be issued if the victim is able to provide a physical description of the perpetrator, leading to what many on campus feel is a cycle of confirmation bias and racial profiling. What wasn’t clear until I spoke with Ezell was how these alerts were actively impacting—often constraining—his access to disciplinary learning and professionalization opportunities, like the National Society for Black Engineering (NSBE):

I did go to physics tutoring a few times at OMSA [the Office of Minority Student Affairs], and ended up getting a really good grade in the class, which was great, [but] I’m not going to lie, I get embarrassed. When I’m in a large crowd of
African Americans students, I don’t like the environment, I just don’t feel comfortable.

Nevertheless, Ezell is succeeding, on the verge of graduating and starting his career as a civil engineer. When I asked him to speak about these successes and his motivations for studying engineering at UIUC, Ezell instantly credited his father, who he described as a real stickler for good grades, always pushing his children to excel academically:

My dad is hard on us when it comes to school. He wants us to keep up with our grades, to have a good life. At times I get frustrated, like “Ugh, get off my back!” but now I see what his reason is. He didn’t go to a college like me, he went to a technical school, he went that route, and honestly, I was going for a community college route, to save my parents money, but he strongly encouraged me to apply to a four-year institution.

As far back as Ezell can remember, it was always his father who sat at the kitchen table with Ezell and his brother and sisters, working out algebra problems and chemistry lab reports. And despite his father’s broad technical knowledge, his pedagogical style often left something to be desired:

When we were in high school and needed help with homework, we would always come to him. But when he explains things to you, he wants you to get it, so his technique of explaining things is like yelling. And so he’d be asking you questions and you’d instantly starting crying, tears just rolling down your face as you’re trying to respond to his question. So my sister and I got together and said “we are never asking him to help us with homework again!”
About two years ago, Ezell discovered one of his father’s old journals on an old bookshelf in his father’s new home in California. Begun sometime when his father was still in high school, this diary is a cross between a dream journal and a day planner:

It asks things like “ten years from now, where do you see yourself?” “What would you like to major in?” It even asks general questions, “What’s your favorite this? What’s your favorite that?” He even recorded his school grades. I probably would have never known most of the information I found in it. It’s not like we talk about that kind of thing. So I would have just gone through life thinking, “I wonder what he did back in school?”

As Ezell read through its pages surreptitiously, he discovered a secret that gave him an entirely new perspective on his father’s persistent pushing and impossibly high standards: his father had always wanted to become an engineer.

Ezell’s discovery happened at a key time in his enculturation process; it was at the same time that Ezell realized that he wanted and needed to transfer out of the Electrical and Computer Engineering program. He was questioning his path into UIUC, his goals for post-graduate work, his academic interests in middle school and high school:

I had always really wanted to do Chemistry, but looking at what my dad had done, I knew that he wasn’t going to be satisfied with that. I felt like he wanted me to do something more. So I looked into engineering. And if I could change it… well, I didn’t know this until sometime recently, but he said to me, “you know, you don’t have to be in engineering” and I just threw my hands up, like “seriously??” in my mind, I was thinking “I did this because I thought I had to impress you.”
In fact, Ezell’s was not the only story wherein a student’s struggle for legitimate disciplinarity was contiguous with the fight to gain a father’s respect.

**Father vs. Daughter**

Research in engineering education (e.g. Margolis & Fisher, 2002) suggests that women who go into technical fields are more likely than their male counterparts to have a parent or relative in that field. Their relatives are most frequently men: fathers, uncles, and brothers. Though some of my female participants reflected this broad pattern, many alluded to unique and idiosyncratic variations that often turned out to be crucial to understanding their experiences as engineering students.

Stephanie is effusive with a self-deprecating attitude that may have something to do with her current predicament; she’s in a kind of academic purgatory between engineering, which was her original major, and kinesiology, the program into which she would ideally transfer. From the very beginning, Stephanie says that she knew she would go into a socio-biological field. She was good at math and science, but was particularly interested in the mechanics of human bodies and the relationship between movement and cognition. Her father encouraged her to apply to the bioengineering program at UIUC instead, urging her away from interests that he worried would not sustain Stephanie later in life. Though a series of textual interactions associated with this process of applying to UIUC, she ended up in nuclear engineering, which she found to be untenable, and which has ultimately caused her to leave the College of Engineering.

Nearly four years ago, while she was still a senior in high school, Stephanie found something she wasn’t expecting while filling out the application form for admission into UIUC (see Figure 5.3 below).
Figure 5.3: The impact of filling out pre-college forms on disciplinary enculturation.
On page seven, where prospective students are asked to declare an initial major, in the blank space where she (and her father) had planned to mark “bioengineering,” there was a special note in box sixteen read. The note read first in bold text, “**For bioengineering majors only,**” and then “Please list a second choice engineering major,” with a blank space for a handwritten answer. Stephanie didn’t know what to write, and when she faltered, her father, who was standing over her shoulder, had her write in “nuclear engineering” as the second choice. It would just be a fail-safe. But, some months later, Stephanie’s happy discovery of her acceptance was tempered with her realization that she was going to be entering the wrong program. Because the bioengineering program was at capacity, she would be entering what is known colloquially as the “NukE” program, nuclear engineering: an academic major about which she knew nearly nothing and was not enthusiastic. Her father urged her to be courageous and give it a shot. She tried and, as she puts it, failed miserably, and has been “cleaning up the mess ever since.”

Sometime during the first semester of her second year here, Stephanie realized that she needed to get out of the nuclear engineering program. She was depressed and on academic probation. She really missed the biological-mechanical components that had made her want to become an engineer, that had made her want to go to college, and she felt isolated in the more chemistry-based and calculus-heavy courses. She knew by then that what she wanted to be doing was kinesiology, that she wanted to go to graduate school and become a physical therapist. But deciding to leave “NukE” was one thing, and figuring out how to explain it to her father was quite another: her dad, she says, “freaked out.”

Despite the tragicomic bent of her story, Stephanie spoke very highly of her father. She talked respectfully, if a bit begrudgingly about his intellect and his successes in school and at
work. But she also recognized his limitations in social and interpersonal settings, situations where she herself excels: “My dad, he’s the stereotypical engineer; he’s very intelligent with the whole academic world, but when it comes to very simple social tasks, he’s always been a little off.” Nonetheless, as a child, Stephanie was frequently disappointed in her inability to meet her father on the level:

When I would ask my dad for Stats help in high school, I’d say “we have to use this formula, but I’m not sure how to plug everything in” and he’d pull out his Statistics book from college and say “Oh, just do it this way.” And it was twenty extra steps! I’d say “No, we’re supposed to use this formula.” So me and my sister eventually stopped asking him for help.

Stephanie’s boyfriend Andy, who is also an engineer, but at a different school about three hour’s drive from UIUC, was sympathetic; he tried to help Stephanie communicate with her father. Ultimately, they succeeded by framing the argument in terms of her new curriculum.

I said “Dad, [Physical Therapy] still requires Calc and Chem and Anatomy and Stats”—it’s the same foundations with not quite as much engineering. We still have to take two semesters of calculus, two semesters of physics classes, like we did in engineering: the first year of Calc, Intro to Stats, Anatomy, Physiology, all the labs, two years of Chem, two years of Bio…which is pretty much engineering for the first two years. He calmed down once he realized that.

At the time of our interactions, Stephanie spoke as though she had made it through the hardest part. Even though she was still struggling to make a case to the department of kinesiology for transferring in, even though she was anticipating several years of graduate school, even though

---

29 Not his real name.
she was still recovering from filling out that seventh page of the admissions form and still working to recover her grade point average, she was happy.

I mean, I don’t consider myself stupid, but I sometimes felt stupid in engineering, like “why don’t I get this? What’s wrong with me? I’m an idiot.” Now I’m more in my element, feeling more intelligent, and my gpa was awesome last semester. Before that I’d been on academic probation. Now, I talk to engineers who don’t like engineering, but are still in it, and I’m like “how do you do it?”

And yet, although she is no long in the College of Engineering, Stephanie is aware that she will never fully leave engineering behind, and not only because her father and boyfriend are engineers; when we spoke, she reported that two of the classes she was currently taking—Ethics and Psychology—were “basically 98 percent engineers!”

\textit{Dirt}

Stephanie was only one of many participants to connect disciplinarity to family, and the analogy raises interesting questions about what it’s like to be in a “nuclear family”-type discipline compared to a “dysfunctional family”-type discipline. Gina and Alan,\textsuperscript{30} for instance, are both seniors in Agricultural Engineering, or AgE, as they call it. But aside from the fact that they both like to work outside, in the dirt, they don’t have much in common. It’s hard to believe they’re even in the same discipline. Gina grew up in the suburbs of Chicago and always enjoyed gardening with her father.

Growing up, my dad gardened a whole lot, and I helped him… I just spent a ton of time with my dad growing up because my mom wasn’t around. I was always

\textsuperscript{30} Not his real name.
outside [with him], playing in the dirt, helping him dig ditches, plant trees. So I’ve just always been in tune with that. When I found out that there was a major for doing that, just playing in dirt, I was so excited.

Alan, on the other hand, is from a small rural town “’bout an hour West ‘a here,” he drawled. He showed up ten minutes early to our second meeting, he said, because he felt bad about forgetting to show up for the first one we’d scheduled. He’s a big, jocular guy, sunburned with close-cropped blond hair underneath a red-and-black checkered trucker hat, which he instinctually removed when he stepped into my office. While Gina’s stories about AgE tended to be about her father, about studying abroad in South America, and about her difficulties communicating with other houses in the Greek system, Alan’s stories all turned out to be about food. Alan’s *de facto* role in his fraternity, where nearly all of the brothers are in AgE, is as resident chef:

> We’re actually cooking goose at my frat house tonight. My brothers are here for the weekend, so I had to show them how to cut up the breasts into strips. My friend and I actually shot [the goose] this winter. And we were fishing all morning today. So we’re gonna have catfish and goose.

When I asked him to tell me how he ended up being the president of a student agricultural society, he said, “Face recognition. And cooking good food for everybody, that’s usually a pretty good advertisement.”

Gina told stories about her sorority—the only engineering sorority on campus—and their struggle to integrate with the rest of the Greek Council on campus. Their sorority is so new that they are still “homeless,” meaning they have not yet been endowed with a sorority house by their alumni association. Thus, although she is a top engineering student and a skilled communicator,
Gina is always negotiating the power dynamics of the Greek system, and she often feels that she must decode the “insider-speak” used by other, more established sororities. Gina was equally conscious of such divides in her own department along political, economical, and class lines, but it was Alan who explicitly described the rift: “We have an interesting mix in AgE. There’s a lot of rednecks like me. There’s a lot of yuppie people from Chicago. But there’s a lot more rednecks.”

Alan, in fact, delighted in calling himself a “redneck,” using the term more than fifteen times during the course of our interview, but he admitted that he was no match for some of his “hardcore redneck” fraternity brothers:

My old roommate is a hardcore redneck. There’s this one kind of duck he likes to hunt, and not because it tastes good. It tastes terrible, it is rancid, and you have to blanch it in milk before you can eat it. The only reason they eat it is because they like to shoot them. He took me hogging last summer, which is where you go catfishing with your bare hands. You stick your hands down in these holes on the bottom of the lake, and some of them will bite your hand and grab onto it. The others you just grab by the jaw and pull them out. He’s in AgE, too. That night we caught sixty pounds of catfish.

Here we can see that Alan’s experience of engineering is inextricably linked to class (“yuppies” versus “rednecks”) and to personal notions of masculinity (hunting, butchering, cooking), but I also noted that when we talked about writing and communication, Alan’s attention turned to his political and religious beliefs. Although he described many opportunities to practice technical writing and communication in his AgE coursework and extracurricular activities, Alan’s textual explorations of his “home” beliefs happened mostly during his two required humanities courses,
where he was isolated from his AgE “family.” At first, he described his first-year writing class as just “alright,” but he later suggested that he’d enjoyed being challenged to defend his beliefs in writing:

I guess my instructor and I didn’t see eye-to-eye. I’m more of a conservative type of person. That’s usually the way it is with most of us [Ag engineers]. He was kind of an anarchist. He did not like “the Man.” [But] it wasn’t even annoying…it was always kind of fun to argue with him, and he liked it, too.

Consider also Alan’s description of a philosophy class he was taking at the time of our interview:

This class all deals with God’s existence. I’m a Christian, I was raised in church and baptized. A confirmation, go-to-church-every-Sunday kind of kid. The TA’s a hardcore atheist, so it’s interesting. It’s pretty much [Freshman Rhetoric] all over again… but you have to have a lot of proo— Well, you don’t have to have as much proof in philosophy, because there’s not a whole lot of proof out there for either side, like hardcore evidence, so. There’s no numbers.

I wondered why Alan paused when he was thinking aloud about how proof is used or defined in different classes and asked if it ever bothered him—as a Christian engineer—about the absence of what he termed “hardcore evidence” for God. He admitted to feeling a little ambiguous on that front, saying “Well, it’s definitely a lot easier to make a point [with numbers and data], but I usually use the Bible as my main source of evidence.” We can see in Alan’s accounts that his argumentative style and conception of proof are an amalgam of religious upbringing, conservative ideology, and engineering enculturation, which began long before he entered AgE. While his training as an engineer has taught him pragmatism, he has retained his personal
attachment to these religious texts and political doctrines, and as a result, has found a new home in his AgE fraternity.

**oSTEM**

Cody, a sophomore in nuclear engineering, has had to make an entirely different kind of home of engineering. Tall, shy, and athletic, with short blond hair, he is the first of his family to go to college and comes from what he called “an economically disadvantaged background.” He has achieved academically, winning a coveted place at the Illinois Math and Science Academy (IMSA), a competitive math and science high school based solely on his grades.

IMSA is technically a public [high] school, but you have to be accepted into it. It’s a very well-rounded education. All of the classes are more difficult, like in my History class we were writing papers. And you still have to take art or music, things like that, which kind of instilled in me that idea that no matter what you want to do, whether you want to be a teacher or an engineer or an artist, it will be most beneficial to be well-rounded and well-balanced as a person.

It was at IMSA that Cody first became excited about engineering: “I got to take a couple of classes…exploring engineering, electronics, where you got to build. For our final project, I made a strobe light.” Cody’s technical capabilities, as well as his appreciation for humanist pursuits and his communicative strengths won him a full scholarship to study nuclear engineering in college, where he has been consistently performing at the top of his class.

Unlike some of my participants, Cody did not seem to recognize a sharp distinction between personal motivations and academic interests; he located the roots of both in his economically disadvantaged youth.
I’m really interested in doing what I can to help other people. That’s something that I really learned at a young age because I was on the receiving end of so many things, Habitat for Humanity, my mom was on the list for that for a long time. Or people helping from church, they would bring baskets. [My] background really helped shape what I would do in high school.

Somewhat reminiscent of Emily’s work with SHPE and WECE, Cody’s labor is driven by his need to “give back.”

I’ve always believed that whatever level you are in society, even if you’re not rich and you don’t have all the money, you can do something to help others. And so I did Habitat for Humanity, and I joined the board in my first year [of high school], and went on seven trips. I was really into doing things like volunteering. I really had a love for it because it’s not like you’re donating money, where you don’t know where that money goes…I was really more into helping people directly. Because you’re building, you’re helping a family, you get to know them. [emphasis mine]

Cody’s semantic conflation of construction and assistance was a strong thematic element throughout our conversation. Cody also used his volunteer work at Habitat for Humanity to explain his current studies in NukE. He chose the field “because I felt that it was a way to do something I was interested in, but that was ultimately helping society.” He hopes that he can use his communicative abilities to improve public perceptions of nuclear power.

Even though he was only a first-semester sophomore at the time of our interview, Cody already had a wealth of texts available to share with me. His PowerPoint presentation about nuclear reprocessing was the first that he thought to tell me about. As he explained, the
ostensible goal of the presentation, which was to familiarize the audience with the “state of the art,” gave rise to another challenge because his chosen topic—nuclear energy—was the most controversial. As a result, his presentation had to present technical information as well as describing some of the arguments against this technology, a backlash that extends beyond the traditional sphere of academic engineering. He was writing not only for other engineers, but for environmentalists, politicians, and other everyday Americans.


\begin{center}
\begin{filecontents}{Plutonium_Uranium_Extraction_PUREX.png}
Plutonium - Uranium Extraction (PUREX)

The PUREX process is a liquid-liquid extraction method used to reprocess spent nuclear fuel, in order to independently extract uranium and plutonium from the fission products. This is the most developed and widely used processes in the industry at present.

PUREX chemicals are monitored because reactors capable of refueling frequently can be used to produce weapon-grade plutonium, which PUREX can later recover.

\end{filecontents}
\end{center}

Figure 5.4: A slide from Cody’s PowerPoint on safety precautions in nuclear technology.

He explains his motivation for choosing nuclear energy and safety precautions for the topic of a recent presentation (Figure 5.4) for an elective, non-engineering course:

There’s this big stereotype and fear from the public about nuclear energy. You hear nuclear and you think Homer Simpson, and there’s the big plants and smoke coming out of it, and glowing barrels of ooze, where you touch it and you’re going to grow a tentacle out of your arm. And I quickly learned that [after] one
or two small mistakes in the nuclear industry, although no one in the United States even got hurt, the perception in the public was so much worse.

Stereotypes are something Cody spends a lot of time thinking about: “In my opinion, to a certain extent, stereotypes, however true or untrue they are, begin in an idea, in a generalization, that is in some way true.” But Cody’s preoccupation with stereotypes is not just because his home discipline is associated with horror films and doomsday dramatics or because engineers like him are stereotyped as being socially inept; Cody is openly gay. He is the president of an organization called “Out in Science, Technology, Engineering, and Mathematics,” or oSTEM, for short.

oSTEM’s main purpose is to enable LGBT engineers to network and develop professionally; Cody organizes resume-writing workshops, interview prep sessions, and forums for members to discuss how they first became interested in engineering and what they hope to achieve with their degrees. oSTEM’s secondary goal is to provide a platform for LGBT engineers to negotiate these dual identities. This is unique, Cody said, “because the LGBT engineering community is not a huge intersection, but there IS one. And that isn’t recognized at all. It’s kind of like this unspoken ‘don’t ask, don’t tell’…” Thus, oSTEM’s goals often overlap, and Cody’s resume-writing experience is one example of the delicate intersection. He explained that after much thought and self-debate, “I finally decided that I’ve put way too much work and effort into [oSTEM] not to put it in there, and so I did.” So Cody rewrote his resume (Figure 5.5 below), feeling confident in his choice to include this claim to the conception, foundation, and presidency of this campus initiative.
Figure 5.5: Cody’s resume, in which he “owns” his foundation of the LGBT group oSTEM.

However, not long after, he was asked to explain the leadership experience during an interview for a summer internship. It did not go well.

One of my first interviews at the beginning of the year was with a company that I really wanted to get an internship with for the summer, and I just remember I met the interviewer, and it was the older guy, just an “Average Joe,” but older, and he was looking at my resume and he asked me about “this o-stem” and I froze,
because I was like, “Crap, now I have to talk about this.” And so I talked about it, and the interview was over pretty quickly. It was really unfortunate.

After the experience, Cody was hesitant to report what had happened, even to his oSTEM family, because he knew his peers needed to be prepared for the worst, but he didn’t want to frighten them. In Cody’s words,

I honestly don’t feel like I have a right answer, it’s something everyone has to face on their own, because that is essentially outing yourself to the employers. And the worst thing about it is—well, I look at this in a good way and a bad way—the person that is interviewing you is supposed to have the same standards, reflect the same viewpoints of the company they’re representing, but that’s not often the case. Personal feelings can get in the way.

As Cody said, personal feelings can get in the way, in both good and bad ways. And yet, as we can see in the stories of Ezell, Emily, Stephanie, Gina, Alan, and Cody, personal feelings not only block or modify disciplinary ways of being, they actively constitute disciplinarity.

**The Link**

A keen, sharp-eyed woman in her early fifties, Kay is a senior secretary who has worked in the Engineering Administration office for almost twenty years. She holds a position of great respect and power in the department and is spoken of by students and fellow administrators as “the boss.” Without Kay, I would never have learned about the secret Iron Ring ceremony described in Chapter 3. When Kay told me about her involvement with the Order of the Engineer, she explained her role as the key contact person for UIUC’s branch:
They [the Order of the Engineer] have different “Links” or chapters, and I’m registered as the…well I’m not even an engineer, so I can’t actually join the Order, but I’m what they call the “Link contact” here. And I had a guy, actually one of the Vice Presidents [of the national Order of the Engineer organization], who emailed me this year to ask about our Link, if we’re active and what we do. It’s because they’re starting to promote this more and more across the United States, so it’s becoming a bigger thing everywhere.

Kay is in an interesting position, as someone who belongs to, and is indeed orchestrating, the College of Engineering, and yet is not an engineer. As you’ve heard her say, since she is not an engineer, she can’t be part of the Order of the Engineer, but it is she who fields questions from faculty, students, families, other staff, as well as companies and businesspeople outside UIUC. She is also responsible for arranging the ceremony every semester:

We provide the ceremony during Engineer’s Week here. And this fall we had a local power station contact us, and they want all of their engineers to join the Order of the Engineer. So one of our professors and a bunch of the students went over to the power plant and did an Order of the Engineer ceremony for them.

Kay’s use of the pronoun “we” is particularly interesting; she feels fully integrated into and invested in the department, to the extent that this linguistic and rhetorical association is not only comfortable, but automatic.

Moreover, Kay has been part of the department longer than most of the staff and many of the faculty, and much longer than any student. She’s watched the department grow and go through many changes. At first, she says, she felt like an outsider, but she has gradually become
more and more conscious of the workings of engineering within the College and in other aspects of everyday life:

Ever since I started here I think I’ve realized that engineering touches more of everyone’s lives than what you really think about. The very first time I went to the Engineering Employment Expo, Levi-Strauss is there! And I thought, they make jeans, what do they need engineers for?!

Kay has also been witness to significant shifts in the discipline of engineering, and she has been particularly cognizant of the gender issue:

There are still gender differences, and I see it. But, I saw it more when I first started working here, because we had older deans, older professors working here, people who had been in here a long time. And they kept talking about “we’re promoting women, we’re going to do this and that,” but you could tell it was still just the good ole boys. But I do see that changing now, because for instance we do have younger deans here now.

As a child, she was a strong student, and even mentioned that she was good in math and science in grade school, “Which is probably why I ended up here,” she said. Nonetheless, she did not pursue higher education until much later in life. Instead, she got married and started a family, as did all of the women in her family and in the little Midwestern town of roughly two hundred people where she grew up. Though all of the men in Kay’s were skilled machinists and technicians, none studied these fields in college:

My dad was in heavy-equipment construction; he was a heavy equipment operator, so all of my brothers have been heavy equipment operators. None of them have ever gone to college. In fact I’m the only person in my family, out of,
you know I have eight brothers and sisters, and I have a sister who is a nurse, but I’m the only other one who has a college degree. My dad never finished high school.

When I asked Kay about her own college experience, she said, a little self-consciously,

Actually, I just went to college last year, just got my degree this past May. I was raised in a small town and being one of nine children, you didn’t go to school. Girls got married and had kids. I always liked school, and I took a class here and there, and then finally in 2004, Parkland [the local community college] offered a thing where you could get your Associates degree in two years by going to school one night a week. So I just decided it was time to do it. My kids were grown…

As she continued her story, it became clear to me that Kay’s decision to go back to school and get her Associates degree was deeply connected to her family situation, and most specifically to her son’s involvement in the war in Iraq: “My youngest son was in Iraq. [Going to college] gave me something to think about, you know, instead of him. If you can’t sleep at night anyway, you might as well be up doing homework.”

Where does Kay belong in Lave and Wenger’s (1991) notion of “legitimate peripheral participation?” She’s an expert and a novice in engineering. Moreover, she is continually shifting around in this space—8 or 10 years ago, one of her superiors retired, and she moved into a new office and took on her responsibilities. She was suddenly new to the job again. But, since she was still responsible for doing her previous job at the same time as the new tasks, she was also an expert. A few years ago, when her soldier son came home from Iraq, he entered the College of Engineering on the G.I. Bill. Now, she is not only an administrative assistant, she’s
an Engineering mom. Her perspective of her work and of the field of Engineering have since shifted dramatically.

After coming home from Iraq, Rick attended the same community college as his mother for two years, and then transferred into UIUC. He is now a junior in the mechanical engineering department, and Kay told me that her understanding of her role in engineering administration and of the college as a whole had changed significantly since Rick had become a student there.

It’s changed since he’s been here, because I see the advice that he’s been given. He got advice in the department, and it didn’t work out very well. When he talked to a dean [in the advising office] he got different advice than he got in the department. And then he was trying to find tutoring, and they don’t have anything really. Most of the tutoring is geared towards freshman and sophomore classes. He just kind of struggled the first year he was here. And I realized then—he would come in and ask me questions—and I realized maybe we’re not covering all the bases, especially for transfer students.

Kay’s multiple roles and identities, as a college graduate, a small-town, blue-collar girl, as “the boss” of the engineering administration office are all infused with her sense of herself as sister, daughter, and mother. Disciplinarity, for Kay, is inflected not only with the familial, but also chronotopically, linked across spaces and times.

“Home discipline,” thus expresses both the extent to which disciplines serve as an extension of personal (home) spaces, but also the way in which disciplines have “homes,” situated in specific moments, places, and people. As we have seen in the experiences and texts of Kay, Cody, Gina, Ezell, Emily, Stephanie, and Alan, engineering has become a kind of “home” for many. Each participant has brought with them pieces of “home,” and we have seen
that in some cases, these pieces are becoming legitimate forms of disciplinary participation, changing the field as it changes each actor. This evolution is not only imperative to engineering—where, as in Lauren Olamina’s post-apocalyptic world, progress (or disciplinary “survival”) depends on innovation and change—but also inevitable, resulting not only from the deliberate actions of students, teachers, staff, and administrators, but also from the phosphorescent afterglow of the conceptual and material things they carry along wherever and whenever they go.
Conclusion: Composing Engineers

Theoretical Contributions

This study has worked to trace academic literate practice beyond traditional mappings of disciplinarity, following in the footsteps of formative scholars (Foucault, Klein, Prior), who suggest that writing and communication are central pathways into, through, and out of disciplines. In each chapter, I have investigated disciplinarity through the literate disciplinary practices of individuals—faculty, students, staff, administrators, alumni—as they move into, through, and out of the walls of the academy. In reporting on interviews, observations, and textual artifacts collected during my 18-month study of the College of Engineering at UIUC, I have discovered much in the disciplinary texts and knowledge production practices that problematize popular notions of disciplinarity.

First, my findings suggest that “expert” and “novice” are not well-defined disciplinary categories. As we see in the textual production practices of engineering students like the freshman Andy in Chapter 2, even newcomers to a discipline can be sufficiently expert so as to significantly impact enculturation. Andy’s GraphSketch website, which he programmed in his spare time, before even entering the engineering program at UIUC, is now used as a free graphing calculator by high school students and teachers in math and science courses. Moreover, as we see in Chapter 2 with students’ use of what I call “genre hacking,” purely corpus-based studies of disciplinary texts are likely to fail to capture the complexity of negotiating new disciplinary and interdisciplinary writing contexts. By indexing external kinds of expertise (argumentative structures, lexis, and technical content), genre hackers can exert
relative authority in situations where they could otherwise be considered inexpert. In Chapter 4, I narrate my own negotiation of expertise and green-ness as a teacher at the ENSIP—relatively expert in English, though a novice in many other respects.

Secondly, I can provisionally conclude that enculturation is often playful and irreverent. Significantly, we can see this playfulness at a range of levels of expertise or insiderness—from student Matt’s Cubs-inspired lab report to Materials Science professor David’s idiosyncratic beliefs about first person and active voice in engineering writing. The teaching texts and practices of engineering educators in Chapter 3 are particularly telling; rather than viewing his disciplinarity with religiosity, as a thing to be reverently passed down from teacher to student, Computer Science professor Lawrence self-consciously infuses his lessons with glib romance (e.g. the random love letter generator). Likewise, Engineering Law professor Laura uses real-but-outrageous legal cases (e.g., the haunted house) to illustrate key engineering concepts.

Third, the “real world” and “school world” are neither apart nor fully harmonious. In Chapter 3, professors Philip and Harry both engage a boundary between academic and non-academic worlds, which both treat as simultaneously firm and permeable. Professor Philip hopes that students will abstract communicative principles from reading Tolkien, but combines literature with more concrete analyses of workplace scenarios to illustrate the “real world” application of his metaphysical lessons. Professor Harry also strives to enrich his students’ enculturation with “real world” stakes (and sometimes threats), yet often deploys the “real world” as a hypothetical game-space for students to explore from the safety of his classroom. For another example, in Chapter 4, though I and other English instructors struggled to retrofit the “business English” of the TOEIC exam into our classrooms, other “real world” issues (the American presidential elections, labor strikes, and intelligent design) easily permeated the
“school world,” and were sometimes formally adopted into the curriculum.

Finally, participants moved disciplinarity beyond, between, and back to institutional spaces, demonstrating that being and becoming an engineer involves an active and irreversible integration of many parts of one’s life. As Cedric suggests in Chapter 4, it is possible to travel beyond the borders of the engineering campus without really leaving. In Chapter 5, we see how Cody’s enculturation integrates his lived experience of socioeconomic status (growing up in a low-income, single-parent home), charitable work (building houses for other underprivileged families with Habitat for Humanity), disciplinary alignment (his empathy for nuclear technology), his homosexuality, professionalization, and leadership. In essence, Cody re-engineers disciplinarity to better suit his personal negotiation of home and discipline, even as he sometimes faces significant challenges to the social implications of this re-engineering.

**Personal Resonances** I have focused on the discipline of engineering for several reasons, not least of which because although knowledge production in engineering is held up as a model for other fields, writing and identity are generally absent from conversations about engineers. I have also been lucky enough to be situated at UIUC, which houses one of the top engineering schools in the country, making access to the engineering community extremely accessible. Yet, there are other reasons, perhaps more significant and certainly more personal, for my interest in studying the literate practices of engineers.

Although I am now part of an English department, in a center dedicated to the study of writing, I frequently think of myself as an engineer, if not of circuitry and concrete, than of words and ideas. As the daughter of two academic engineers, I grew up with a unique level of access to the world of engineering, and my world continues to be comprised of many peculiar,
soft links to the pure and applied hard sciences. For instance, although my Chapter 2 reference to the Sokal Hoax of 1996 is oblique, my own personal experience of the hoax was quite different. I was about thirteen, sitting in a restaurant in Raleigh, North Carolina as my father told me the story. Later, as a graduate student in a humanities department, I would meet many of the key players in the Sokal event—some only in text and others in the flesh.

Interestingly enough, my father recently had dinner with Nathan Sokal—father to the infamous Alan—who goes by “Nat” (Figure 6.1). Though Nat is in his eighties, he is still very much involved in research and consulting, and often attends the same conferences as my father. In this instance, my dad was attending a conference presentation by one of his graduate students, and after the talk, Nat called out to my father to come sit next to him. After the conference had finished for the day, they went out to eat to talk over a model my father had developed to explain a peculiar set of data Nat had sent him.

**Figure 6.1**: Nathan “Nat” Sokal, during a dinner meeting with my dad in June 2008

---

31 Notably, just as my father has had much to do with my home discipline, fathers figured heavily in the stories I heard from many participants in this study; Gina’s father, who raised her as a single parent and taught her to love gardening, which led to her becoming an agricultural engineer; Ezell and Stephanie’s fathers who more or less clandestinely pushed them into the discipline; Kay’s father, who did not even graduate from high school, but who taught her to have respect for the machinery of the world.
My father described the dinner (which took place, incidentally, on Father’s Day) as very pleasant:

When the workshop was over, he and I went to a French restaurant, called the Peasant Bistro, for dinner. We talked for two or three hours over lamb chops and wine. He’s a lot of fun. Alan [Sokal] and Becky [me] both came up after the technical stuff had turned to kids.

The hoax did not come up.

Family aside, there are some more formal disciplinary connections between my personal background as a researcher and the field of engineering. While I myself have never studied engineering, one of my undergraduate degrees is in mathematics. The years I spent walking the halls of a department of mathematics and computer science has afforded me not only with lexical and linguistic pathways into engineering conversations, but also a very concrete sense of empathy for the difficulty of technical studies. Meanwhile, my other bachelor’s degree in English has meant that I also spent a good amount of time in college translating between two very different fields, often feeling less than successful. I have developed much admiration for scholars—C. P. Snow, Alan Lightman, Donna Haraway—who gracefully flout the boundaries between disciplines, calling to mind the words of Thor Heyerdahl that opened Chapter 4.

While my research experience was overall a positive one, not all of my encounters with engineering were as graceful or pleasant. Some participants were interested in my project; others were skeptical. Some were willing to extend a disciplinary welcome to me based on my long-ago training in mathematics and computer science; others approached me and my home discipline with derision. Most challenging of all were my interactions with one engineering
faculty member who talked about his students as lazy idiots and imbeciles. This was particularly difficult because my readings of his class materials had led me to believe that there was much to be desired in his course directives and feedback to students. Another very well-meaning instructor held ideas about writing pedagogy that seemed disturbingly antiquated and reactionary (especially in his use of current-traditional rhetorics). Nonetheless, these two cases felt exceptional, like relics of an old-guard approach to conceptualizing disciplinarity and learning, as the rest of my participants illustrated how willing engineering students, teachers, and staff are to think expansively about communication, enculturation, and discipline.

A Critical, Feminist, Playful Project

The primary methodological tool I set out to use in the course of this research is what Prior (2008) refers to as “flat CHAT”: the blend of actant-rhizome theory (derived from the work of Foucault and Deleuze and Guattari and developed by Latour, Callon, and Law) and sociohistoric theory (derived from Vygotsky, Luria, and Leont’ev, and developed by Engeström). Following Prior’s proposal to combine the equitability or “flatness” of ANT with the inter-mediational lens of CHAT, I have worked to attend equally to the literate activities of many different kinds of engineers (including some participants who might not usually count as engineers), and to seek out relations between these disparate participants, texts, and practices.

However, in the course of the study, I have taken on another heuristic, which I have come to think of as “feminist play,” a mix of Haraway’s (1991) concept of blasphemy/irony, Jarratt’s (1998) Foucault-inflected project of destabilization, and Richardson’s (1997) disciplinary irreverence. One of my main goals going into this project was to explore lived experiences of everyday boundary-breakers, and the lens of “feminist play” has helped me to
identify certain patterns in my participants’ texts, actions, and words: pedagogical acts of
playfulness, moments of disciplinary fluidity, and elements of the personal in the institutional.

I sought out engineering faculty who were teaching writing-intensive courses, as I sensed
not only that these instructors would be the most likely to be able to speak to the intersections
between engineering and other fields, but also because I feared that engineering students would
have less room to play than their teachers. What I found surprised me. To be sure, there were
many rule-breakers amongst the faculty in the College of Engineering. Even more surprising to
me was my discovery that students were just as frequently and freely playing with their
enculturation into the discipline of engineering. While at somewhat of a disadvantage given the
traditional classification of novice, many of the students in Chapter 2 were able to use texts to
demonstrate their expertise and to deploy both communicative and technical sophistication in the
interest of securing a good grade (Rob), coveted internship (Gina), or lifelong career (Leslie).

Richardson and St. Pierre (2005) have called writing a method of inquiry, identifying the
value in producing qualitative research texts that matter and the importance of the discovery
process inherent in the writing process. To be sure, I have discovered much about literacies and
practitioners of engineering in the course of writing up my larger inquiry project, particularly as
I have struggled to weave together participants’ perspectives and to account for the ways in
which their stories diverge. In Chapter 5, Emily’s experience of ECE is strikingly different
from the story that Carol Livingstone’s data tells. The field that Stephanie describes hating so
passionately—NukE—is the same field that has become a “home discipline” to Cody. And
while Gina and Alan are model students in the same department—AgE—they come from
drastically different home situations, and it is hard to imagine them cohabitating the same space.
These contradictions and discontinuities have been hard to make sense of. And yet, such
extreme variations in participants’ descriptions of their fields also indicate an ultimate convergence—in the pattern of idiosyncratic accounts—which has been equally dramatic. Perhaps this is because writing research frames writing not only as method, but as a topic of inquiry. Writing research allows us to see writing as more than just a way to access social practices, but in terms of the literate activities that structure and punctuate those social practices and our lived experiences of discipline. As Prior (1998) explains, disciplinary writing involves “dynamic processes of appropriation, externalization, and alignment in and through which persons, artifacts, practices, institutions, and communities are being produced, reproduced, and transformed in complexly laminated social and material worlds” (p. 287). Nonetheless, when I asked questions about participants’ composition practices, I did not anticipate the multiplicity of accounts of disciplinarity. Some of the most consequential texts—recipes, resumes, Bible passages—were totally off the disciplinary map. In addition to the canonical disciplinary texts—like lab and research reports (as discussed in Chapter 3), which are typically captured in studies of disciplinary genres (e.g., Berkenkotter & Huckin, 1995)—participants in this study referenced and provided samples of numerous other kinds of texts critical to their practice of engineering. Through this kind of “alter-canon”—mission statements, resumes, application forms, novels, religious texts, and poetry—we see how poorly our typical maps of engineering represent literate life.

Moreover, participants routinely indexed emotionally-charged issues—race, gender, class, faith, and sexuality—in connection to their enculturation into and continued participation in engineering. Thus, while Biglan (1973) and Becher’s (1989) taxonomies propose that members of “hard-applied” sciences are “purposive and pragmatic,” my findings suggest
engineers are frequently just as “reiterative; holistic; personal; value-laden” as Becher supposes humanists to be (p. 35-37).

In response to the abstract question, “What is an engineer,” Florman (1996) replies “engineers are what they do” (p. 117). Having heard and reported my participants’ accounts, I am struck by the realization that my questions about writing enabled participants to access physical (and therefore idiosyncratic) practices. Instead of responding in rote or abstract ways, these participants were able to think about the writing they do as engineers, about the “doing,” which, according to Florman, constitutes being an engineer. In posing questions about embodied practices like writing, presenting, drafting, and coding, I glimpsed the relationship between individual, physical bodies and disciplines as participants considered the way they use their physical bodies in their everyday disciplinary compositions—reading recipes and collaborating with frat brothers to cook a goose; blending problem solving with stewardship to mentor little girls at a Lego competition; communicating empathy by building houses for underprivileged families and applying this empathy to the nuclear energy industry. Thus, if engineering has a reputation for being cold and impersonal, as being the “other” of the two cultures, I wonder if it is not, in part, the fault of those of us who study engineers. Perhaps we have not been asking quite the right questions and could discover so much more if we were to investigate these “home disciplines,” these embodied engagements in academic work and disciplinary experiences of race, sex, sexual orientation, and faith. We must also proceed with these investigations with humanity, for if we hope to understand disciplinarity, we must never forget the very real (human) bodies within (disciplinary) bodies.

Just as Hanisch (1969) argued that the personal is political, I have found that in disciplinary enculturation, the personal is institutional. Through the lens of feminist play, my
ethnographic evidence has increasingly called into question traditional classification schemes (e.g. objectivity in Chapter 1, legitimate peripheral participation in Chapter 2, the mangle of practice in Chapter 4), and I have begun to formulate a new, critical-feminist framework for the mapping of disciplinarity. This framework, which I introduced in Chapter 5, calling it “home discipline,” traces literate disciplinary practices beyond traditional academic sites as well as manifestations of idiosyncratic “nondisciplinary” practices within such institutional spaces. “Home discipline” encourages researchers to attend both to external forces of enculturation and what Leont'ev (1981) calls the “self-assertive motives” of participants in order to fully capture the practice of discipline (pp. 21-22). In so doing, “home discipline” not only achieves a more comprehensive tracing of acculturative associations, it also open a space for recovering key disciplinary involvements of women, people of color, and queer engineers. There is much more work to be done to reveal how seemingly distinct disciplines have always been laminated networks of activity populated with unruly texts, spaces, and human beings that are disruptive of the white male status quo. However unique engineering may be, this kind of feminist inquiry is significant regardless of discipline.

**Implications for Pedagogy and Practice**

**A Dialogic View of the Economy of UIUC** In terms of impacting pedagogy and practice in writing studies, my goals are not unlike Miller’s (1991) in *Textual Carnivals*. Just as I am wary of stovepipe models of academia that configure disciplines as discrete entities, so am I suspicious of configurations of the institution that take disciplinary hierarchies as a foregone conclusion. As Miller (1991) writes, “teachers and students of writing in American higher education…have for some time been the subjects of a marginalizing and negative—but
nonetheless widely believed—myth” (p. 1). For Miller, disciplinary marginalization is not only a myth, but one compositionists actively encourage. Just as Miller urges her compositionist readers to acknowledge the cultural, political, and economic privilege that teaching positions afford them and to recognize the ways in which hegemonic power structures also serve them, I hope these chapters do some of the work of showing non-engineers (writing teachers, philosophers, lawyers, secretaries, fathers, children) their primacy in the “carnival” of engineering enculturation.

The Bakhtinian carnival, which Miller (1991) invokes in her title, indexes “the peculiar situation of a transitional site within an institution, from a simultaneously low and culturally privileged position that creates…blurred identities and mixed perceptions” (p. 1). Bakhtin’s (1965) carnival imagines a unified whole: when the high and the low coalesce, when heterogeneity blurs into homogeneity, the collectivity allows for heightened awareness and individual renewal. By playing up the carnival metaphor, Miller invites compositionists, like medieval peasants, to see themselves not as sad women in the basement, but as queens for a day. However, as Ewald suggests (1993), casting composition (or engineering, for that matter) as a carnival cannot alone undo hegemony (pp. 345-346). For this reason, I am more compelled to deploy Bakhtin’s (1981) concept of dialogic imagination. Enculturation, like language, is dynamic and relational. Just as dialogic texts engage multiple other texts, writers, and contexts, so does enculturation into engineering engage fantasy literature (as in Philip’s course in Chapter 3), composition (David’s use of William’s Style guide in Chapter 3), baseball (Matt’s lab report in Chapter 3), religion (the French Muslims’ take on intelligent design in Chapter 4), politicians (Obama in Chapter 4), and poets (Kipling in Chapters 1 and 3), and much else.
Ultimately, however, this dissertation is less about classroom practices, or even about engineers, than it is about the ways in which texts and talk evidence the processes of discipline-making and person-making at work in everyday spaces. I have endeavored to show that discipline is something dialogic that happens inside as well as outside of classrooms, during college as well as before and after, and on personal as well as professional levels. In this sense, my title, “Engineering Literacy: The Practice of Discipline,” is meant to invoke the engineering of literacies moreso than the literacies of engineers, and to suggest that discipline is more usefully and more accurately conceived as a practice—a verb—than it is a discrete thing or space—a noun.
References


& J. Paradis (Eds.) *Textual dynamics of the professions: Historical and contemporary studies of writing in professional communities*. Madison, WI: University o


College Composition and Communication 44(3), 331-348.


International writing scholarship and collaborative research: Attending to the waves between continents (Preconference Workshop). Conference on College Composition


University of Illinois at Urbana-Champaign Management Information Web Resources. (2010). *Campus profile 2000-2010 and Student enrollment reports 2000-2010.*
Retrieved January 20, 2010 from Division of Management Information
http://www.dmi.illinois.edu/.


*Enculturation* 5(2). Retrieved August 3, 2009 from
http://enculturation.gmu.edu/5_2/wardle.html.


Appendix A: Sample Recruiting Letter to Instructor

Dear Professor XXX,

I’m writing in regards to the Engineering course you are teaching this semester, ___[Course Number/Name]____. My name is Rebecca Bilbro, and I’m a PhD student here at the U of I conducting a study with Professor Paul Prior in the Center for Writing Studies on how engineering departments produce engineers: how students, instructors, and staff write, communicate, work, and learn in engineering departments.

Your work as a researcher and a teacher of an Advanced Composition course is especially interesting, as we are studying how writing and other modes of communication (such as talking, drawing, calculating) figure into the processes of becoming an engineer. Thus, we are interested in the genres of work, the kinds of language, and the institutional structures (such as courses, labs, clubs, and other activities) around which students’ writing is organized. The purpose of this study is both to advance our knowledge about these practices and to use the data collected to inform teachers about these practices (and thus hopefully to improve the success of the curriculum and retention/graduation rates).

If you are willing to participate in the research, the initial step would be an interview (30 minutes to an hour) in which you and I would talk about your courses, your teaching philosophies and strategies, your understanding of Engineering as a discipline, and the curriculum here at the U of I. We could look at your syllabus as well as any assignment prompts or other documents that you think might help illustrate the contexts in which your students learn to be engineers and the expectations and learning goals you have for them.

The interview may give me all the information we need, but sometimes it’s useful to see an example of a phenomenon or method an instructor has described in the interview, so I might ask to (for example) observe a class session or speak with one or two of your students. Sometimes I might ask if you would be willing to do additional interviews so we can go into more depth on particular issues.

You can, of course, always say no to any of this, and I cannot conduct any research without first getting signed consent forms from you (and from any students whom I interview or whose work I look at).

Let me know if you have questions about any of this; you can email me at rbilbro2@illinois.edu or call me on my cell at 714-4606. If you’re interested (and I hope you are!), please let me know what days/times would be convenient for you for an interview.

Thanks for your attention, and I look forward to hearing from you.

Cheers,
Rebecca Bilbro
Appendix B: Sample Recruiting Letter to Student

Dear XXX,

I’m writing in regards to your work as President/Founder of _____[Club/Student Organization]____. My name is Rebecca Bilbro, and I’m a PhD student at the U of I studying how engineering departments produce engineers: how students, instructors, and staff write, communicate, work, and learn in engineering departments.

Your work with _____[Club/Student Organization]____ is particularly interesting because I am studying how writing and other modes of communication (such as talking, drawing, calculating) figure into the processes of becoming an engineer. Thus, I am interested in the kind of work you do, the languages you use, and the institutional structures (such as courses, labs, clubs, and other activities) around which your learning and writing are organized.

I would like to interview you about your experiences in the Engineering department and with_____[Club/Student Organization]____. In the interview (which would take 30 minutes to an hour), you and I could talk about your work with your RSO, your coursework, and possibly other things you are doing for your professional development as an engineer.

You can, of course, always say no to any of this; whether you decide to participate in the research or not will have absolutely no effect on your relations with or your access to any services at the University of Illinois.

Let me know if you have questions about any of this; you can email me at rbilbro2@illinois.edu. If you’re interested (and I hope you are!), please let me know what days/times would be convenient for you for an interview.

Thanks for your attention, and I look forward to hearing from you!

Cheers,
Rebecca Bilbro
Appendix C: Interview Protocols

 Semi-structured / Stimulated Elicitation
 Interview Protocols for Students, Instructors, and Staff
 Writing, Communicating, Working, and Learning in an Engineering Department at UIUC
 Paul Prior (pprior@illinois.edu) and Rebecca Bilbro (rbilbro2@illinois.edu)

Across the different phases of the project, semi-structured interviews will be conducted. The protocols that follow indicate the kinds of questions that will be asked. Some questions, such as those in A. 1. (a.) below, are clearly questions that would be asked initially; others, like A. 1. (b.), are questions that might be repeated across a series of interviews. The protocols indicate the kinds of issues that the interviews will cover. Depending on the situation and the participant's willingness, interviews might go into more or less depth or be focused on only some of the issues, and follow-up questions might be more or less extensive. In the case of a series of interviews, later interviews will be more likely to involve follow-up questions for clarification and elaboration and stimulated elicitation questions.

Central Research Questions
What does it mean to be an engineer, and how does one become an engineer? How does one teach/help someone to become an engineer? What roles do writing and communication play in this enculturation? The interview protocols below suggest the kinds of questions that will be asked of different categories of participant.

A. Interview Protocol – Students

1. Opening Questions
   (a) How long have you been at the U of I?
   (b) How is the semester/school year going so far? What kinds of things are you working on?

2. Schooling/Enculturation
   (c) Which engineering class(es) are you taking?
   (d) What kinds of assignments and lessons are you doing in your engineering class(es)?
   (e) Can you tell me about a specific assignment that you have worked on? What did you have to do? What was the purpose of that assignment?
   (f) How do you see assignments such as these fitting into the work that a professional engineer does?
   (g) Do you feel you are learning an Engineering vocabulary or a way of speaking/writing like an engineer?
   (h) What does it mean to speak or write like an engineer?
   (i) What kinds of engineering-related things do you do outside of class (clubs, study groups, programming, etc)?

3. Engineering Identity
   (j) Do you consider yourself an engineer?
(k) What sort of engineer are you (or will you be)?
(l) What does “being an engineer” mean to you?
(m) What kinds of activities/practices do you do as an engineer?
(n) Tell me about a time when you first began to see yourself as an engineer. Do you think this is a typical experience? Why or why not?

4. Follow-up/Closing Questions
(o) You haven’t mentioned ----
(p) Is there anything else you’d like to add?

B. Interview Protocol – Instructors
1. Opening Questions
(a) How long have you been at the U of I? What did you do before you came here?
(b) How is the semester/school year going so far? What kinds of things are you working on?

2. Schooling/Enculturation
(c) Which engineering class(es) are you teaching?
(d) What kinds of assignments and lessons have your students been doing in these class(es)?
(e) Can you tell me about a specific assignment that they have worked on? What did they have to do? What was the purpose of that assignment?
(f) How do you see assignments such as these fitting into the work that a professional engineer does?
(g) Do you feel you are teaching an Engineering vocabulary or a way of speaking/writing like an engineer?
(h) What does it mean to speak or write like an engineer?
(i) What kinds of professional engineering-related activities are you involved in (research, publishing, grant-writing)?

3. Engineering Identity
(j) How long have you been an engineer?
(k) What sort of engineer are you?
(l) What does “being an engineer” mean to you?
(m) How did you learn to become an engineer (in school? On the job? Through teaching?)
(n) When did you first begin to see yourself as an engineer? Do you think this is a typical experience? Why or why not?

4. Follow-up/Closing Questions
(o) You haven’t mentioned ----
(p) Is there anything else you’d like to add?

C. Interview Protocol – Staff
1. Opening Questions
(a) How long have you been at the U of I? How long in the Engineering department? What did you do before you came here?
(b) How is the semester/school year going so far? What kinds of things are going on in the department this time of year?

2. Departmental Activities
   (c) Could you describe your role in the Engineering department? What are some of your responsibilities and common tasks?
   (d) What kinds of interactions do you have with students (discussion of procedures, applications, aid, etc)?
   (e) What kinds of interactions do you have with faculty?
   (f) How do these interactions take place (face-to-face? Text? Email?)?

3. Engineering Identity
   (g) What does “being an engineer” mean to you?
   (h) From your perspective, do students develop a kind of engineering identity while they are in school? If yes, when and how does this take place? If no, do you think they develop this identity after they graduate and get jobs?
   (i) What does being part of an engineering department mean to you?

4. Follow-up/Closing Questions
   (j) You haven’t mentioned ----
   (k) Is there anything else you’d like to add?

D. Stimulated Elicitation Protocol

Stimulated elicitation interviewing may be done with public texts (e.g., from engineering websites), course documents (e.g., syllabi, assignments), or student texts. Stimulated elicitation interviews may be also be done with objects (e.g., a piece of laboratory equipment, a device that a student has made in class). The interviewee may be an author of the document, an actual reader or a potential reader. The following provide an idea of the kinds of questions asked in a stimulated elicitation.

1. For authors/producers
   a) Tell me about how this (a passage in a document or a device) was written/produced.
   b) (For a text passage) If I suggested deleting this (or replacing with different text), would you agree? Why or why not?
   c) (For a device) Can you show me how this works? Please explain as you go.

2. For readers/users
   a) Please read this passage (or describe this part) and tell me how you understand it or how you would use it.
   b) (For a text passage) If I suggested deleting this (or replacing it with different text), would you agree? Why or why not?
Appendix D: Rob’s Homework

1. Show the detailed steps involved in the following base conversions. In each case, solve for X.
   a. 100\textsubscript{10} = X\textsubscript{2}
      \[\begin{align*}
      100/2 &= 50 \quad r=0 \\
      50/2 &= 25 \quad r=0 \\
      25/2 &= 12 \quad r=1 \\
      12/2 &= 6 \quad r=0 \\
      6/2 &= 3 \quad r=0 \\
      3/2 &= 1 \quad r=1 \\
      1/2 &= 0 \quad r=1
      \end{align*}\]
      \[X\textsubscript{2} = 1100100\]
   b. 1101011\textsubscript{2} = X\textsubscript{10}
      \[\begin{align*}
      (1\times2^6) + (1\times2^5) + (0\times2^4) + (1\times2^3) + (0\times2^2) + (1\times2^1) + (1\times2^0) \\
      64 + 32 + 0 + 8 + 0 + 2 + 1 = X\textsubscript{10} = 107
      \end{align*}\]
   c. 157255\textsubscript{8} = X\textsubscript{16}
      \[\begin{align*}
      157255\textsubscript{8} &= 001 101 111 010 101 101 \text{ in } 2\textsubscript{16} \\
      &= \text{D E A D} = X\textsubscript{16}
      \end{align*}\]
   d. 1011.101\textsubscript{2} = X\textsubscript{10}
      \[\begin{align*}
      (1\times2^3) + (0\times2^2) + (1\times2^1) + (1\times2^0) + (0\times2^{-2}) + (1\times2^{-3}) \\
      8 + 0 + 2 + 1 + .5 + 0 + .125 = X\textsubscript{10} = 11.625
      \end{align*}\]
   e. FAC.ADE\textsubscript{16} = X\textsubscript{8}
      FAC.ADE\textsubscript{16} = 1111 1010 1100 . 1010 1101 1101\textsubscript{2} = 111 110 101 100 . 101 011 101 110\textsubscript{2} = 7 6 5 4 . 5 3 3 6 = X\textsubscript{8}
   f. 341.44\textsubscript{8} = X\textsubscript{10}
      \[\begin{align*}
      (3\times8^2) + (4\times8^1) + (1\times8^0) + (4\times8^{-1}) + (4\times8^{-2}) \\
      192 + 32 + 1 + .5 + .0625 = X\textsubscript{10} = 225.5625
      \end{align*}\]
   g. 365\textsubscript{8} = 1100 0010\textsubscript{2}
      \[\begin{align*}
      (1\times2^7) + (1\times2^6) + (0\times2^5) + (0\times2^4) + (1\times2^3) + (0\times2^2) + (0\times2^1) + (0\times2^0) \\
      128 + 64 + 0 + 0 + 0 + 0 + 0 + 2 = X\textsubscript{10} = 194
      \end{align*}\]
      If X = 7, \[147 + 42 + 5 = X\textsubscript{10} = 194, X = 7\]

2. Show the detailed steps (i.e. borrowing, carrying) involved in the following arithmetic calculations:
   a. 1011 + 101
      \[\begin{align*}
      1111 & \text{ carries} \\
      1011 & \\
      + & 101 \\
      \hline
      10000
      \end{align*}\]
   b. 110001 – 10011
      \[\begin{align*}
      \downarrow & \downarrow & \downarrow & \downarrow 1 \\
      - & 0 & 1 & 0 & 1 & 1 \\
      \hline
      1 & 1 & 1 & 1 & 0
      \end{align*}\]
   c. 101 \times 1010
      \[\begin{align*}
      101 & \\
      \times & 1010 \\
      000 & \\
      101 & \\
      000 & \\
      101 & \\
      \hline
      110010
      \end{align*}\]
d. BC x 8D

\[ \begin{align*}
BC & \quad D \cdot C = 13 \cdot 12 = 156 = 9 \cdot 12 = 9C \\
x \ 8D & \quad D \cdot B = 13 \cdot 11 = 143 = 8 \cdot 15 = 8E \\
9C & \quad 8 \cdot C = 8 \cdot 12 = 96 = 6 \cdot 0 = 60 \\
8E & \quad 8 \cdot B = 8 \cdot 11 = 88 = 5 \cdot 8 = 58 \\
60 & \quad 9 \cdot E + 0 = 9 \cdot 15 = 24 = 1 \cdot 8 = 18 \\
58 & \quad 1 + 8 + 6 + 8 = 23 = 1 \cdot 7 = 17 \quad //Carry \ over \ 1 \\
678C & \quad 5 + 1 = 6 \quad //Carry \ over \ 1 
\end{align*} \]

e. 41 - 2F3

\[ \begin{align*}
41 & \rightarrow -1 \ast 2F3 \quad //Reverse \ subtraction \ and \ multiply \ by \ -1 \\
- 2F3 & \rightarrow -41 \\
2B2 & \rightarrow 41 - 2F3 = -2B2 
\end{align*} \]

3. Consider the following circuit:

a. Write the truth table for \( F(A,B,C) \).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>( F(A,B,C) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>F</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>F</td>
<td>T</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>F</td>
<td>T</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>T</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

b. Convert the circuit (without simplification) to a Boolean expression.

\[ F(A,B,C) = (A \cdot C)' + C \cdot B + A \]

c. Use the laws of Boolean algebra to simplify the expression.

\[ F(A,B,C) = (A \cdot C)' + C \cdot B + A \]
\[ = ((A' + C') + C) \cdot B + A \quad //De \ Morgan’s \ Law \\
= (A' + C' + C) \cdot B + A \quad //Associative \\
= (A' + T) \cdot B + A \quad //Negation \ Law \\
= (T) \cdot B + A \quad //Domination \\
= B + A \quad //Identity \ Law 
\]

d. Convert the simplified expression back to a circuit, using only AND, OR, and NOT gates.

\[ A \bigoplus B \rightarrow F \]

4. Any Boolean function can be expressed as a composition of the functions AND, OR, and NOT. In other words, you could theoretically build a circuit to implement any Boolean function using only AND, OR, and NOT gates. Explain why this is the case. (Hint: use the fact that any function can be expressed as a truth table.)
There are 16 different Boolean functions. Using the AND and OR gates to combine two values and the NOT gate to invert any single value, it is possible to build all 16 gates. For instance, NOR and NAND gates can be built by placing a NOT gate directly after an OR and AND gate, respectively. Since any function, like AND, NAND, NOR, etc., can be expressed as a truth table, it is simply a matter of connecting the gates, inputs, and outputs in such a way that the truth tables agree for that of the actual gate and that of the AND, OR, and NOT gate configuration.

5. It turns out that any Boolean function can also be implemented using only AND and NOT gates. Explain why.
As mentioned in the response to the previous question, circuits are considered logically equivalent when they have the same truth table. In order to use just AND and NOT gates to represent all of the 16 boolean functions, first build an OR gate by using three AND gates, taking the inputs of A'B, AB', and AB each into their own AND gate, then combining the output from all three into one. The result is an OR gate made from just AND and NOT gates. Using a similar process and the newly constructed OR gate, it is possible to translate all Boolean functions into circuits.

6. Using only NOR gates, show how to build (Intermediates are represented)
   a. A NOT gate
   b. An AND gate
   c. An OR gate

   Use a total of six NOR gates.

7. Consider the function \( F(A,B,C,D) = (AB+C)(B+C'D) \)
   a. Show how to compute \( F' \) using repeated applications of DeMorgan's laws.
   \[
   F' = ((AB+C)(B+C'D))' \\
   F' = (AB+C)' + (B+C'D)' \\
   F' = (A'C' + B'C') + (B'C + B'D') \\
   F' = A'C' + B'C' + B'C + B'D' \\
   F' = A'C' + B'(C' + C + D') \\
   F' = A'C' + B'
   \]
b. Show how to compute $F'$ using the concept of duality.

$$F = (AB+C)(B+C'D)$$
$$F = ABB + BC + ABC'D + CC'D$$
$$F = AB + BC$$

Dual of $F = (A+B)(B+C)$

$$F' = (A'+B')(B'+C')$$

c. Express $F$ in sum-of-minterms form.

$$F(A,B,C,D) = AB + BC = \sum m(7,13,15)$$

d. Express $F$ in product-of-maxterms form.

$$F(A,B,C,D) = \prod M(0,1,2,3,4,5,6,8,9,10,11,12,14)$$

e. Express $F'$ as a product of maxterms.

$$F'(A,B,C,D) = (A'+B')(B'+C') = \prod M(7,13,15)$$

9. Give an expression for the number of Boolean functions of

a. two variables.

$$2^2 = 4$$

b. $n$ variables.

$$2^n$$

10. Simplify these functions using the laws of Boolean algebra. Clearly show the steps of your derivations. State which axioms you are using at each step.

a. $A'C' + A'BC + B'C$

$$(A + C)' + (A + B' + C')' + (B + C')'$$

De Morgan's Law

$$(A + C)'(A + B' + C')(B + C')'$$

De Morgan's Law

$$(A + CA + AB' + CB' + AC' + CC')(B + C')'$$

Distributive

$$(A + CA + AB' + CB' + AC' + F)(B + C')'$$

Negation Law

$$(AB + AC' + CAC + AB'B + AB'C + CB'B + CB'C' + AC'B + AC'C')'$$

Distributive

$$(AB + AC' + ABC + F' + F + AB'C' + F + F + ABC' + F)'$$

Negation Law

$$(A(B + C') + BC + B'C + BC')'$$

Distributive

$$(A(B + C') + C'(B + B'))'$$

Distributive

$$(A(B + C'))'$$

Idempotent Law

$$(AB + AC')'$$

De Morgan's Law

$$(A' + B') (A' + C)$$

De Morgan's Law

$$(A^2 + A' + B') + A'C + B'C$$

Distributive

$$A' + A'B' + A'C + B'C$$

Idempotent Law

$$A' + B'C$$

Absorption Law

b. $(A+B)(A' + B')$

$$(A + B)' (A' + B')$$

De Morgan's Law

$$(A'B')(A' + B')$$

De Morgan's Law

$$(A'B'A' + A'B'B)$$

Distributive

$$(A'B' + A'B')$$

Idempotent Law

$$A'B'$$

Idempotent Law

c. $ABC + A'C$

$$ABC + A'C$$

$$(ABC)' (A'C)')$$

De Morgan's Law

$$(A' + B' + C')(A + C')')$$

De Morgan's Law

$$(A'A + A'C' + B'A + B'C' + C'A + C'C')'$$

Distributive
(F + A'C' + B'A + B'C' + C'A + C')'
Negation Law
(A'C' + B'A + B'C' + C'A + C')'
Idempotent Law
(AB + C')'
Absorption Law
(AB')'(C')'
De Morgan's Law
(AB')'C
Double Negation Law
(A' + B)C
De Morgan's Law
d. BC + B(AD + C'D)
BC + B(AD + C'D) Distributive
BC + BAD + BC'D
Distributive
B(C + AD + C'D) Distributive
B(C'(AD)'(C'D)') De Morgan's Law
B(C'(A' + D')(C + D'))' De Morgan's Law
B((C'A' + C'D')(C + D'))' Distributive
B(C'A'C + C'A'D' + C'D'C + C'D'D')' Negation Law
B((C'D')' + C'D')' Idempotent Law
B(C'D') Absorption Law
B(C + D) De Morgan's Law
e. (D'E + C' + ED'C')(DEC + A(D+E') + AC)
(D'E + C' + ED'C')(DEC + A(D + E') + AC) Distributive
(D'E + C' + ED'C')(DEC + AD + AE' + AC) Absorption Law
D'E'EC + D'EAD + D'EAE' + D'EAC + C'D'EC + C'AD + C'AE' + C'AC Distributive
D'EC + D'EAD + D'EAE' + D'EAC + C'D'EC + C'AD + C'AE' + C'AC Idempotent Law
D'EC + F + F + D'EAC + F + C'AD + C'AE' + F Negation Law
D'EC + C'AD + C'AE' Absorption Law
((D'EC)'(C'AD)'(C'AE'))' De Morgan's Law
((D + E' + C')(C + A' + D')(C + A' + E))' De Morgan's Law
((DC + DA'E + DD' + E'C + E'A' + E'D' + C'C + C'A' + C'D')'(C + A' + E))' Distributive
((DC + DA'E + F + E'C + E'A' + E'D' + F + C'A' + C'D')'(C + A' + E))' Negation Law
(DCC + DCA' + DCE + DA'C + DA'A + DA'E + E'CC + E'CA' + E'CE + E'A'C + E'A'A' + E'A'E + E'D'C + E'D'A' + E'D'E + C'AC + C'A'C + C'AE + C'D'C + C'D'A' + C'D'E)', Distributive
(DC + DCA' + DCE + DA'C + DA'A + DA'E + E'C + E'CA' + E'CE + E'A'C + E'A' + E'A'E + E'D'C + E'D'A' + E'D'E + C'AC + C'A'C + C'AE + C'D'C + C'D'A' + C'D'E)', Idempotent Law
(DC + DCA' + DCE + DA'C + DA'E + E'C + E'CA' + F + E'A'C + E'A' + F + E'D'C + E'D'A' + F + F + C'A' + C'A'E + F + C'D'A' + C'D'E)', Negation Law
(DC + DA'E + E'C + E'A' + C'A') Absorption Law
(DC)'(DA'E)'(E'E'C)'(C'A')' De Morgan's Law
(D' + C')'(D' + A + E')'(E + C')'(E + A) (C + A) De Morgan's Law
(D' + D'A + D'E' + C'D' + C'A + C'E')'(E + C')'(E + A) (C + A) Distribution
(D' + D'A + D'E' + C'D' + C'A + C'E')'(E + C')'(E + A) (C + A) Idempotent Law
(D'E + D'E AE + D'E'E + C'D'E + C'AE + C'AE + D'C' + D'E'C' + C'D'C' + C'AC' + C'E'C')'(E + A) (C + A) Distributive Law
(D'E + D'A + F + C'D'E + C'AE + F + D'C' + D'AC' + D'E'C' + C'D'C' + C'AC' + C'E'C')'(E + A) (C + A) Negation Law
(D'E + D'A + C'D'E + C'AE + D'C' + D'AC' + D'E'C' + C'D'C' + C'AC' + C'E'C')(E + A) (C + A) Idempotent Law
(D'E + D'C' + C'A + C'E') (E + A) (C + A)  
Absorption Law
(D'EE + D'C'E + C'AE + C'E'E + D'EA + D'C'A + C'AA + C'E'A) (C + A)  
Distributive
(D'E + D'C'E + C'AE + C'E'E + D'EA + D'C'A + C'A + C'E'A) (C + A)  
Idempotent Law
(D'E + D'C'E + C'AE + F + D'EA + D'C'A + C'A + C'E'A) (C + A)  
Negation Law
(D'E + C'A) (C + A)  
Absorption Law
D'EC + D'EA + C'AC + C'AA  
Distributive
D'EC + D'EA + C'AC + C'A  
Idempotent Law
D'EC + D'EA + F + C'A  
Negation Law
((D'EC)' (D'EA)' (C'A))'  
De Morgan's Law
((D + E' + C') (D + E' + A') (C + A'))'  
De Morgan's Law
((DD + DE' + DA' + E'D + E'E' + E'A' + C'D + C'E' + C'A') (C + A'))'  
Distributive
((D + DE' + DA' + E'D + E' + E'A + C'D + C'E' + C'A') (C + A'))'  
Idempotent Law
(DC + DA' + E'C + E'A' + C'DA' + C'E'A' + C'A')'  
Absorption Law
(D'C' + E'C + E'A' + C'A)  
De Morgan's Law
(DC)' (D'A)' (E'C)' (E'A')' (C'A)  
De Morgan's Law
(D' + C') (D' + A) (E + C') (E + A) (C + A)  
De Morgan's Law
(D'D' + D'C' + AD' + C'A) (E + C') (E + A) (C + A)  
Distributive
(D'E + C'AE + D'C' + C'AC') (E + A) (C + A)  
Idempotent Law
(D'E + C'AE + D'C' + C'A) (E + A) (C + A)  
Distributive
(D'E + C'AE + D'C' + C'AE + D'EA + C'AC + C'A'C + C'A'A) (C + A)  
Negation Law
(D'E + C'AE + D'C' + C'AE + D'EA + C'AE + C'A'C + C'A'A) (C + A)  
Idempotent Law
(D'E + C'AE + D'C' + C'AE + D'EA + C'AE + D'C'A + C'A) (C + A)  
Absorption Law
D'EC + C'AC + D'EA + C'AA  
Distributive
D'EC + F + D'EA + C'AA  
Negation Law
D'EC + D'EA + C'A  
Idempotent Law
((D'EC)' (D'EA)' (C'A))'  
De Morgan's Law
((D + E' + C') (D + E' + A') (C + A))'  
De Morgan's Law
(DDC + DE'C + DA'C + E'DC + E'E'C + E'A'C + C'DC + C'E'C + C'A'C + DDA + DE'A + DA'A + ED'A + E'DA + E'A + C'DA + E'A + A + C'DA + C'E'A + C'A')'  
Distributive
(DC + DE'C + DA'C + E'DC + E'C + E'A'C + C'DC + C'E'C + C'A'C + DA + DE'A + DA'A + E'DA + E'A + A + C'DA + C'E'A + C'A')'  
Idempotent Law
(DC + DE'C + DA'C + E'DC + E'C + E'A'C + F + F + F + DA + DE'A + F + E'DA + E'A + F + C'DA + C'E'A + F)  
Negation Law
(DC + E'C + DA + E'A)'  
Absorption Law
((C + A) (D + E'))'  
Distributive
(C + A)' + (D + E')'  
De Morgan's Law
(C + A)' + D'E  
De Morgan's Law
1. **INTRODUCTION**

Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) are relatively recent developments in technology that allow for more and more precise machining of parts. With the help of computers, a part can be conceptualized, sketched and modeled, and from there automatically dictate to a machine how to accurately fabricate that part.

Since breaking into the mainstream during the 1980’s, CAD/CAM has grown to the point where almost all man-made products are created using the process. Many different softwares have emerged along these lines, with each having advantages and disadvantages in terms of user-friendliness and display. The programs allow engineers to render a design in three-dimensions to exact specifications, and then convert the geometry into a machine tool programming language for interpretation by a mill or another machine.

There are several advantages that are provided by CAD/CAM over traditional human machining of parts. First and foremost, the accuracy that is able to be obtained in part production is much higher than ever before. It eliminates human errors that could result in wasting of materials and time as well as preventing failure of the part later. Another benefit of using the automated system is the much faster fabrication time it allows, creating a more efficient process.

Along with those advantages come some drawbacks of the method. For an operator to be able to create the CAD part and then feed it into the machine requires extra training and expertise in both the program and in the machine tool language. Once cost of training combined with equipment and software costs, the set-up of a CAD/CAM operation can be very expensive. Another drawback is the limitation on how efficient the drill paths drawn by the computer can be. While the computer can come up with a reasonable path, they don’t have the intuition and reasoning a human operator could apply, and often will take longer than is necessary, compounding machine wear and slowing down production time.

In this report, ProEngineer was used to design a part that will be fabricated using computer-aided manufacturing. The finished model was converted into a numerical control code called G-Code for use by a Tormach 3-axis CNC mill, which machined a final part. The objective was to investigate every step of the fabrication process, notably the use of ProE in part design, the
process of converting to G-Code, and the roughing, re-roughing and finishing sequences during machining.

2. METHODS

The first step of the whole CAD/CAM process was to come up with a design. The part was created in ProEngineer and conformed to several specific requirements. It was created in an aluminum block of 3” by 1.5” by 0.625”, however was confined to within 2.5” by 1.25” by 0.25” in order to avoid the drill getting too close to the vice grips that held the block in place. The constriction on depth (0.25”) was mainly to lower the machining time by reducing material that needed to be removed. A third imposed constraint was that the design needed to have at least one connection to the sprue runner gate system for later use during injection molding. The model was also required to have several features, including draft angles of at least 1 degree, curved surfaces and 3D features.

Once the part was modeled, it was converted to G-code for interpretation by the mill. The first step was to select the beginning and ending parts in the system, for which the original aluminum block was used as the beginning and the ProE model was used as the endpoint. The part was then oriented in order for the connection to coincide with the sprue-gate system so that material would be able to be injected into the mold. The mill window was established to include the entire design in it. The next step was to input specific mill sizes to tell the program what tools would be used in production.

There are three sequences during the machining process: roughing, re-roughing and finishing. The roughing process is the first cut into the block and roughly etches out the shape of the design, doing the bulk of the material removal. The re-roughing process follows and continues to remove material and get the cuts to within a specific distance of the final cut, preparing for the finishing process. Finally, the finishing process gets each cut to its final dimensions as well as going back over surfaces to give a smooth surface finish.

After all the paths for each step of the machining was drawn, a G-code was created to input the paths into the mill. The G-code was saved in the form of a TAP-file for use in the machining process. It was inputted to the mill, which recreated the paths drawn out earlier while using a coolant to constantly prevent the drill from overheating or breaking.
3. RESULTS & DISCUSSION

3.1 Final Milled Piece

The final milled piece showed some interesting features. While the top surface is smooth to the touch, visually it doesn’t look smooth. The inside of the cut is ridged with the lines left by the drill and is rough to the touch. The curved edges on the inside of the deeper cut are surprisingly well formed, although slightly altered by the aforementioned ridges. The cuts made are mostly symmetric and nice-looking, but there are a few lines where the drill would move across the cut from one side to the other and left a line. The rounded edges on the bear’s face appear to have been difficult in machining, as they have a relatively small radius and transitioned into the portion of the cut that was too narrow for the drill to fit in.

3.2 Differences Between Model and Final Part

Observation of the final product shows several interesting results. Most noticeably, the eyes that were intended to be cut into the block didn’t turn out. This was because of a fault in the original Pro-E design, namely that the drill wasn’t able to fit into the small space left for the eye. Another thing that stands out as different are the small indentations left by the tip of the bit as it cut out the pattern. These indentations follow along with the drill’s path, showing the line it took in the part’s fabrication. Other than the significant flaw and the small lines left by the drill, the final design, shown in figure 1a, closely mimics the model shown in figure 1b.

![Figure 1- a) Pro-E Model of Part, b) Final Milled Part with Defect Area Highlighted](image)

One more area that didn’t come out completely as expected was the nose, which was modeled as a cylinder with straight edges, and came out rounded. This is visible in figures 2a
and 2b, which show a zoomed-in view of both the model and the final part, giving a better look at the side walls of the nose.

![Figure 2- a) Zoom-in on Pro-E Model, b) Zoom-in on Final Milled Part](image)

In these pictures, there is no doubt that the nose came out differently than expected. This is also true of the edges of the eyes, which were similarly turned from vertical to a curved surface. These occurrences were likely due to the drill bit being too big to large to drill down another level and leave the side of the cylinder completely vertical. These problems, and the earlier problem involving the drill being too small to carve out a path, could be ameliorated with use of either a smaller drill bit or by scaling the part bigger to allow the drill more material to work with and bigger features to cut.

### 3.3 Benefits of CAD/CAM

During every step of the fabrication process, CAD/CAM provided a substantial improvement over the alternative methods. During the design phase, a design was easily created and brought to specific dimensions within a short period of time, as opposed to being drafted repeatedly until it satisfied the designer’s intention. CAD allowed for simpler adaptations to be made on a design and for the creator to exactly match his design intent. Once mastered, CAD software can enable a designer to model even complicated parts within just hours.

Using CAM process, students involved in the lab were able to make their own parts with minimal supervision using the designs they created. This is something that would be unthinkable prior to the advent of CAM, as the necessary machining skills would need to be mastered over years. The precision offered by the machine is remarkable as well, assuming the design is within the specifications necessary to maximize it. It cuts out risk of human error and inefficiencies that could otherwise occur when relying on human operators. Overall, CAD/CAM makes the creation of parts much easier than it otherwise could have been.
4. CONCLUSIONS

In this lab, a part was created and brought from a ProE design to a physical model with use of computer-aided design and computer-aided manufacturing. After taking into account several constraints and necessary features, the design was converted into a G-code to be interpreted by the milling machine, which manufactured the part in 20 minutes time.

CAD/CAM has numerous advantages that make it an incredibly useful process in machining parts. Chief among them are the precision and eradication of possible human errors and reduction in the time necessary to machine the part. It does also carry some disadvantages, including having an expensive set-up and a high degree of specialization required to run it.

It was clear from the results that the final product was very similar to the ProE model, with a few differences that were mainly a result of design problems. The design didn’t exactly meet specifications in that it had a pathway that was too narrow for the drill bit to fit through, leading to a different final product than expected. The nose and eyes also had rounded edges instead of the vertical ones called for in the design. In retrospect, these were issues that should have been avoided during the design process. The one non-design based difference was that the drill bit left small indentations along the path it travelled. It isn’t a huge deal in the end, but will lead to a slightly ridged surface when the part is used for injection molding.

In the future, this lab could be improved by having smaller drill bits that would allow the machining to be more precise, or by using larger initial blocks that allow for more interesting designs to be made. Also, it may be enlightening to do more specific examination of the G-code to give the student an idea of what it is the machine is actually interpreting.