

ABSTRACT OF THESIS
COMPLEXITY OF THE WRITING ENVIRONMENT:
A CASE STUDY AT THE EDGE OF CHAOS

The purpose of this exploratory case study is to investigate the possibilities and connections among complex adaptive systems and the writing processes of three Colorado State University students in an upper-division composition course taught in a computer-networked classroom as it relates to their physical-material environment. I attempt to fill in the gap of knowledge concerning how the physical-material environment interacts with the complex social and psychological dimensions to affect college students' composition processes. Three primary research questions drive this case study: how does the class setting shape activity within the classroom? What are student attitudes towards reading, writing, and computers? What material resources do students use when they approach a composition assignment?

Utilizing classroom observations, writing samples, interviews, surveys, screen-capturing software, and audio and video recordings of the writing processes of students, I analyze three students' writing processes from multiple perspectives to capture an in-depth understanding of how some individual students write. Overall, my findings suggest that the writing process is a complex adaptive process. The most significant areas that this case study illuminates for further research is the impact of economic and social initial conditions that students grow up in developing their writing skills in terms of access to information technologies, interactions with writing, and attitudes towards writing.

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This study raises more questions than it answers, but it provides insight into further areas of inquiry. In conclusion, I suggest future research into the writing process as a complex adaptive process by examining the writing process with metaphors such as phase space and writing at the edge of chaos to increase our understanding of students' writing processes.

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY JARED A. TOMLIN ENTITLED COMPLEXITY IN THE WRITING ENVIRONMENT: A CASE STUDY AT THE EDGE OF CHAOS BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS.

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THESIS

COMPLEXITY IN THE WRITING ENVIRONMENT:
A CASE STUDY AT THE EDGE OF CHAOS

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The views expressed in this thesis are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.

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Chapter One

Introduction: Approaching Complexity

“I think the next century will be the century of complexity.”
Stephen Hawking

Within the past several decades, several researchers have argued, that writing is a complex, adaptive, and recursive process. Conceptualizing the writing process through the lens of chaos and complexity theory potentially offers new insights and a fuller understanding of how writers write because these frameworks directly describe complex adaptive systems. Scholars, theorists, and educators obviously maintain diverging opinions about which theorists they agree with in constructing their personal understandings of the writing process. Similar to the story of the blind men and the elephant, composition theorists have used multiple approaches to explain and understand the act of writing through focusing on specific aspects while failing to present a comprehensive treatment of the process as a whole.

One group of theorists with a specific perspective, from which this thesis begins, is scholars who focus on the impact of technology on writing and the teaching of writing. Scholars such as Cynthia Self, Gail Hawisher, Charles Moran, Christina Haas and many others have traced the history and dramatic transformation of the writing environment changes over the past thirty years. With the advent of recent technological advances allowing students improved access to digital resources, it behooves administrators and educators to understand the act of writing in these electronic environments and how, or if, these new tools such as the networked computer classrooms, Internet, e-mail, online

discussion forums, and access to online databases and writing center resources enhance or inhibit the composition processes and products which students produce.

The purpose of this case study is to explore the possibilities and connections among complex adaptive systems and the writing processes of college students as it relates to their physical-material environment. I will explore the idea that the environment in which writers compose can be considered a complex adaptive system formed from interrelated and interdependent complex systems, independent agents, and their respective environmental structures and processes. Through an exploratory study conducted during the spring of 2004, I address how the physical-material environment interacts with some of the complex social, economic, and cognitive dimensions to influence college students' composition processes. Utilizing classroom observations, writing samples, interviews, surveys, screen-capturing software, and audio and video recordings of the writing processes of students enrolled in an upper-division writing course offered in a computer-networked classroom at Colorado State University (CSU), I examined three students' writing processes over the course of one semester in their natural writing environments.

Origin of Thesis

Like all narratives, this case study is a snapshot of three students' writing processes told *in medias res* of their lives, but the most significant beginnings of this thesis began during the fall semester of 2003. Following recommendations from Professor Sarah Sloane, I registered for E 633A: Exploring Theory: Chaos, Complexity, and Writing taught by Professor Kate Kiefer. Kate designed the course to explore ideas

including symmetry, pattern recognition, chaos theory, complexity theory, cellular automata, and socio-cognitive reading and writing theories. This course cultivated my curiosity of the implications of complexity theory in the world. In my thesis, I will explore the potential values and insights that an interdisciplinary approach surrounding complex adaptive systems, nonlinear dynamics, and emergence can offer to compositional studies.

Several texts I read in Professor Kiefer's course, as well as related texts, reified my fascination with the concepts of sensitive dependence on initial conditions, the emergence of order from apparent chaotic behavior, or the idea that simple rules in deterministic systems can produce complex and unpredictable behavior. A few of the texts that were initially influential in my research were Margaret Syverson's, *The Wealth of Reality: An Ecology of Composition*, Paul Cilliers', *Complexity and Postmodernism: Understanding Complex Systems*, James Gleick's *Chaos: Making a New Science*, Tom Stoppard's *Arcadia*, and Mark C. Taylor's *The Moment of Complexity: Emergent Network Culture*. Many other articles and texts emerged over the past year with beneficial insights and perspectives that I incorporated throughout the literature review, discussion, and conclusion. As we discussed some of the central claims of chaos and complexity theories, I started to wonder whether these theories were applicable to composition studies and the writing process. I decided to investigate these questions further through this thesis and opportunities to investigate these connections were possible at CSU.

Research Questions

I have noticed multiple shifts in my personal writing process from high school to graduate school and I imagine most people can cite numerous changes in the ways that they have approached writing over the course of their lifetimes. The most dramatic difference that I have noticed in my personal writing process is through the technology that I employ when conducting research, writing, revising, and receiving feedback on my texts. I used to write out all of my papers by hand, but now I do almost all of my research, writing, and revising on the computer. I readily identify with Sherry Turkle's statement when she writes, "When I want to write and don't have a computer around, I tend to wait until I do. In fact, I feel that I must wait until I do" (29). I can type, edit, and revise much faster than I can write by hand, which makes handwriting feel inefficient because I will have to take more time to rewrite the same text again on the computer. Technology has changed the way that I write, when I write, and ultimately, I wonder if it has not dramatically changed *how* others and I write.

The technological revolution of the information age has dramatically changed the physical environments of many composition classrooms as well as the communication capabilities and options available for students and teachers. Access to e-mail, online discussion forums, Internet resources, online databases, blogs, MUDs, MOOs, and ebooks, make it possible for students to do research without ever going to the campus library in person. The temporal and spatial constraints of scheduled course meeting times do not confine classroom discussions because students can post their thoughts, opinions, and questions through online discussion forums or over e-mail. Students can research scholarly articles through the university databases and read entire books online. Students can e-mail scholars, researchers, professors around the world with questions relevant to

their areas of study. Students at CSU can e-mail drafts of essays to the CSU writing center for feedback and comments. Observing the rapid changes in the educational environment raises many questions about how these new online environments affect students and their writing practices.

My initial driving research question was: can chaos and complexity theory be applied to the writing process? Is it generative to examine the writing process as a complex adaptive system? Is the writing process chaotic? Is it a combination of chaos and complexity? Some of the related questions attempt to understand the process that students experience as they write. I am more interested in the process that students experience as they write than the text that they produce at the end; however, I also recognize that, in a pragmatic sense, how teachers evaluate the final product strongly influences students' perceptions, motivations, and valuations of writing. Although I was unable to consider these questions in my study, I am intrigued by questions such as: If students wrote a text at a different time of day, under different circumstances, or in a different physical environment, would the process or the product differ in significant ways? How can changes in a person's life, relationships, or environment affect their writing process? How do students' writing habits change over the course of a semester and what influences those changes? How do cycles of stress, hunger, fatigue, or illness affect the writing process? Many of these questions are too broad in scope to deal with comprehensively in this thesis; however, these are the questions motivating my research and could be significant to consider for the field of composition. Although I do not address all of these questions directly in my thesis, I suggest areas where further research might find answers. This thesis describes how the students interact with each other and

their physical environment throughout an upper-division writing course. When formulating my research design, I wanted to explore the external and internal physical dynamics that students experienced as they wrote papers over the course of a semester for a class designed to provide them with a wider understanding of their writing process. How does the class setting shape activity within the classroom? What are student attitudes towards reading, writing, and computers? What material resources do students use when they approach a composition assignment? It is with these questions that I began to frame my research aims and methodology for my research.

Exploratory Aims

Unfortunately, there is neither the space nor the time available considering the scope of this thesis to delve into all of these related topics with adequate depth. My intention is to recognize and suggest some of the potential avenues, connections, concepts that could provide writing theorists and educators a productive way to conceptualize composition. My overall aim for this thesis is to survey some of the connections and areas of further research that I have found to offer the greatest potential for a fuller understanding of the writing process and complexity theory's applicability to composition studies. This case study is an exploration into the possible connections and incongruities between the writing process and chaos and complexity theory. I want to see if chaos and complexity theory provide any useful metaphors, examples, models, or concepts that bring additional understanding or explanation to the process of composition. The principle aims of this research are:

- To explore the existence of evidence for or against connections between the concepts associated with chaos and complexity and the writing process
- To explore the writing processes of three college students over the course of a semester and investigate students' decisions regarding their composing process with regard for an awareness of their environment and available resources
- To examine the proposal for the future research in the potentially generative linkages between complexity and the writing process in the material environment

Although not a specific research aim, it is my hope that my research might encourage more research into the complexity of the writing process as well as catalyze interdisciplinary considerations and discussions. I developed these research aims while assuming an inquisitive stance by remaining open to the possibility that there may not be any viable or worthwhile connections between writing and chaos or complexity. However, as I made observations, interviewed students, and recorded writing sessions, it became evident that there are some worthwhile connections between writing and complexity.

Significance of a Case Study

Composition theorists and educators also have a professional and ethical responsibility to pursue a greater understanding of the writing process because teaching writing is a way of presenting reality. As James Berlin wrote, "To teach writing is to argue for a version of reality, and the very best way of knowing and communicating it" (766). In the same article, Berlin argued that rhetorical theories diverge from each other in the ways that the writer, reality, audience, and language are perceived—both as

separate units and as the relationships between units. Educators have a duty and responsibility to their students and the credibility of the composition field to establish representations of writing that are as credible and accurate as possible. Therefore, since many tomes of literature argue that chaos and complexity dominate reality, educators should consider the implications of these theories in writing.

The immediate impact of my research is limited, but like a butterfly that flaps its wings, it is my hope that this thesis will be one small iteration, a stimulus, that will join other works building towards a shift in composition studies that will embrace complexity and conceptualize the writing process in ways that will result in substantial contributions to the field. Obviously it is not possible to establish any generalizable conclusions from a case study of three college students' composing processes over the course of one semester, but I hope through the description of these students' writing processes that readers will be able to recognize similar characteristics, attitudes, and habits that resonate with their own or other students' writing processes in a productive way.

In the remainder of the introduction, I will briefly present some of the key characteristics of complex systems and interdisciplinarity as a means to provide a framework for the remainder of the thesis allowing the connections to emerge from the text as well as in the minds of the readers in a dynamic interaction of thoughts through the complex network of shared ideas. In order to justify the potential for any of these connections, it is essential to understand the theoretical framework and fundamental concepts associated with complex systems.

Nonlinear Complex Systems: A Brief Introduction

The science of complex adaptive systems is the attempt to understand that which is hidden. Complex systems is a new field of science studying how parts of a system give rise to the collective behaviors of the system and how the system interacts with its environment. Social systems forming out of interacting people, the brain forming out of interacting neurons, molecules forming out of interacting atoms, and the weather forming out of interacting air molecules are all examples of complex systems. The field of complex systems has implications for all traditional disciplines of science, as well as economics, management, and the humanities. It focuses on certain questions about parts, wholes, and relationships. These questions are relevant to all traditional fields. The study of complex systems is about understanding indirect effects. Problems that are difficult to solve are often hard to understand because the causes and effects are not obviously related. Pushing on a complex system at one point often has wide-ranging effects because the parts are interdependent. Several specialists in the field such as Murray Gell-Mann, John Holland, and Chris Langton have conjectured that these elusive principles and interactions within complex adaptive systems drive many natural processes throughout the universe and even many hegemonic forces that we construct and perpetuate through social, economic, political, and cultural systems. This has become more and more apparent in efforts to solve societal problems or avoid ecological disasters caused by human actions. The field of complex systems provides a number of sophisticated tools, some of them are conceptual helping us to understand these systems, some of them are analytical allowing us to study these systems, and some of them are digital enabling us to model these systems.

Today, we live in unprecedented age of complexity, technology, information, and change. Complexity is still a burgeoning science and researchers from many different disciplines are investigating the relevance of nonlinear dynamics, complex adaptive systems, and emergence to everything from animal populations, artificial intelligence, weather systems, global market fluctuations, and corporate business models to social behavior within any colonies and global political systems. Complexity theory remains polyonymous as a result of this multidisciplinary investigation into nonlinear systems. The definitions, terms, and concepts in complexity theory continue to change, evolve, and emerge as researchers investigate properties of nonlinear systems. Scholars and theorists from many disparate disciplines are approaching complexity theory as it relates to their field of study; therefore, there are multiple terms, perspectives, examples, and metaphorical understandings of similar phenomena and the underlying characteristics of complex adaptive systems.

Even the term complex adaptive system invokes diverse meanings for different researchers. Gell-Mann wrote that a distinguished professor at the Santa Fe Institute at the conference on The Mind, the Brain, and Complex Adaptive Systems said, “A scientist would rather use someone else’s toothbrush than another scientist’s terminology” (11). For example, what Gell-Mann categorizes as a complex adaptive system, John Holland calls an adaptive agent. Holland uses the term complex adaptive system for a composite complex adaptive system, consisting of agents that are adapting to one another, such as organisms in an ecological system or investors in a market. What Gell-Mann calls a schema, a term borrowed from psychology referring to a pattern used by the mind to grasp an aspect of reality, Holland calls an internal model. Today, many of these ideas

remain nebulous and the terminology differs from author to author. As researchers work on complex systems more, they will gain fuller understandings of their defining characteristics and create some order from the confusion.

For many people, confusion, uncertainty, and unpredictability create a desire for simplicity that leads to a vain yearning to return to fundamental principles and foundational values. Stability, predictability, and equilibrium can be deceptive, because contrary to classical science's explanations thus far, they are but transitory eddies in an incessantly complex and turbulent flux. Copernicus said that the earth is not the center of the universe. Bach composed beauty through interwoven and reciprocal melodies and harmonies. Poincaré explained that determinism allows for unpredictability. Freud argued that our conscious self is the tip of an unknowable psychological iceberg. Escher challenged our perceptions of the world through our senses in his artwork. Heisenberg's uncertainty principle showed that physical determinism fails on short temporal and small spatial scales in the sense that the position and momentum of a subatomic particle cannot both be determined precisely at the same time. Gödel proved that any consistent formal system powerful enough to contain arithmetic must contain at least one proposition whose truth or falsity cannot be proven within the system. Turing's theorem and test demonstrated that there are limits to logical analysis. The beautiful irony is that the result of each one of these discoveries is an appreciation that the natural world is richer and more structurally complex than we had previously thought. Scholarly interest in chaos and complexity derives from our desire to pursue an understanding of the distinctions between what we consider chaos and what we perceive as order. By considering some of the epistemological shifts that have occurred in the sciences through the development of

chaos and complexity theory, we find similar shifts on a timeline of the history of composition, (particularly if composition has responded to the paradigm that has guided complexity theory). From a historical survey of the writing theories I will discuss in the next chapter, it is evident that multiple perspectives emerge from conflicting ontologies, epistemologies, methodologies, teleologies, and ideologies.

For over 300 years, physics was based on linear systems. The word linear refers to the fact that if you plot such an equation on a graph, it emerges as a straight line. Indeed, some of nature appears to work precisely in this way. However, much of nature is not linear, and cannot be accurately understood through linear systems. The brain certainly does not function in a linear manner, nor does the economy with its chaotic cycle of booms and recessions. A non-linear equation is not expressed in a straight line, but takes into account the irregular, contradictory, and frequently chaotic nature of reality. One basic scientific issue that has remained unresolved until recently was the relationship between disorder and order in the universe. The second law of thermodynamics describes the increase of entropy throughout a closed system and implies a universe as evolving from order to disorder; still, biological and social evolution show us the complex emerging from the simple. How is this possible? How can structure arise from disorder?

Complexity theory provides some answers to this question. We know now that non-equilibrium, the flow of matter and energy in unstable states, may be the source of order. Perhaps one of the most generative ideas that I will explore throughout my thesis is the phenomenon known as the edge of chaos, a phrase coined by Chris Langton, but also known as self-organized criticality (Per Bak), the moment of complexity (Mark Taylor), or combinatorial optimization (Stuart Kauffman). According to complexity theorists, all

significant change takes place between too much and too little order, exactly where complexity flourishes. Essentially all of these scholars are describing the observable phenomenon that many natural systems thrive in a delicate balance between order and disorder.

Interdisciplinarity

My hope for this thesis is that by analyzing the writing process through this lens educators and students will become more aware of the wider influential factors and gain additional insight into the complexity of the writing process. I also hope that my analysis and synthesis of complexity will initiate interdisciplinary discussions. Useful insights and understandings emerge by retracting from the overspecialization of the academic disciplines to look for ways to recombine and synthesize some of the ideas from various fields of study. I think that it is generative to look at how disparate theories, approaches, and methods result in novel understandings of our world. That is part of what I am attempting to do in my thesis: combine the theories from what appear to be divergent disciplines and find ways that they can inform one another in ways that an individual discipline may not typically consider. I think that complexity theory may provide an insightful way to model or come to understand the writing process.

The information age empowers interdisciplinary research in ways that have not been as readily available as they are now. Increased digital network communications as well as rapid and available access to synchronous information, research, and theories encourages integration among disciplines. Public databases on the Internet allow different disciplines to share each other's vast knowledge. Given the enormous amount of

available information, the new challenge becomes the art of selection, searching, and filtering elements from the labyrinth of information to make useful connections.

An interdisciplinary approach is the methodological embodiment of complexity theory because life is a web of richly interconnected complex adaptive systems behaving in linear and nonlinear ways. If we are to understand why individual systems behave the way they do, we must also examine how interconnected systems are influencing the subject of study. James Gleick describes the institutional resistance to interdisciplinary research when he describes how tightly compartmentalized the scientific community had become. “Biologists had enough to read without keeping up with the mathematical literature—for that matter, molecular biologists had enough to read without keeping up with population biology, physicists had better ways to spend their time than sifting through the meteorology journals” (31). The overspecialization of scientific disciplines combined with the increased flux of information inhibits the integration of multiple disciplines and creates barriers to synergistic discoveries. If there is to be any hope of moving beyond the current impasse, humanists and scientists must find ways to talk with and learn from each other. Ultimately, I advocate a vision of interdisciplinary projects working toward solving problems that have not been, or cannot be, adequately addressed using the theoretical and methodological tools and preferences of a single discipline.

Coming Attractions

The next chapter traces some of the parallels between the epistemological shifts in composition and the sciences with a brief history of the writing process and the similarities and differences between the science of chaos and complexity theory. I will

provide a brief overview and synopsis of the sparse literature that has explored writing through the lens of chaos and complexity theory. I will describe some of the key concepts from chaos theory and move to complexity theory. While the mathematics and physics behind chaos and complexity is, well, complex, the main concepts should be readily understood by a general audience. Although I am simplifying, chaos tends to be described in terms of increasing entropy, indeterminacy, self-similarity across scales, and complex behavior emerging from deterministic systems often governed by sets of simple rules. Complexity theory, however, focuses more on the emergence of self-organized behavior in a non-deterministic system, information transfer between many interconnected agents with limited localized knowledge, order emerging from disorder, and sensitive dependence on previous history. In an attempt to embody an interdisciplinary approach, I will describe some relevant literature sampled from disciplines and issues, such as writing theory, artificial intelligence, materiality, and the digital divide. All of these issues are deeply embedded in the social, economic, political, and historical moment in which they occur. I will explore the concepts in literature review as a means of foreshadowing the analysis, comparisons, and relationships dealt with in more detail in the discussion section of chapter four.

In chapter three, I will outline my methodology and explanations for the research decisions as well as my epistemological, ontological, and basic assumptions about my research process strengths and weaknesses in addressing my research question and accomplishing my research aims. I will provide a description of the research setting, participants, data collection, and data analysis methodologies I employed. I used multiple methods of data collection in an effort to achieve the triangulation of data required for

most qualitative research. The greatest strength of my methodology is the synergistic combination of multiple methods of data collection from which to perceive, compare, and understand the dynamics involved in the composition process.

Chapter four will provide the results and discussion of my research findings told through a narrative of the classroom dynamics and survey responses followed by each case study participant's writing process over the course of the semester. Following the presentation of the results, I discuss some of the general patterns, trends, and aspects that I observed through the use of observations, surveys, interviews, video recordings, and screen capturing software, which support or conflict with the concepts associated with complexity theory. In the discussion of my analysis, I suggest that composition is poised for an epistemological shift that parallels the shift in the sciences towards a greater understanding of nonlinear dynamic systems. I conclude my discussion with an exploration of potential generative themes.

To conclude my research in chapter five, I will summarize the main findings from my collective case study and evaluate my research regarding my original research aims. I reflect on the limitations of my research and review some of the links and ambiguities with complexity theory. I speculate about some of the implications of chaos and complexity theory in composition, particularly in terms of computer-assisted instruction. I offer numerous possible metaphors and ways to imagine the writing process in terms of complexity theory, one of which is visualizing the writing process or even competing writing theories in terms of phase space dynamics. Additionally, I suggest that the nonlinear nature of composition, while complex, dynamic, and chaotic at times, has remarkable potential for making personal and social changes for both teachers and

students, and that ultimately, this hopeful vision might encourage further research in understanding the writing process.

Chapter Two

Literature Review: Entering the Chaos and Complexity

Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static “snapshots.” It is a set of general principles—distilled over the course of the twentieth century, spanning fields as diverse as the physical and social sciences, engineering, and management...During the last thirty years, these tools have been applied to understand a wide range of corporate, urban, regional, economic, political, ecological, and even psychological systems. And systems thinking is a sensibility—for the subtle interconnectedness that gives living systems their unique character.

- Peter Senge

Overview

Essentially, there is a dearth of literature directly discussing connections between complex adaptive systems and the writing process. The history of composition has considered multiple approaches to the writing process, yet a comprehensive unified theory of writing, if one exists, remains elusive primarily because the focus of each theory of writing remained too reductive without adequately accounting for the nonlinear nature of writing. Nevertheless, many previous articles, studies, and books have discussed similar phenomena or alluded to ideas related to chaos and complexity, which are vital components of complex adaptive systems. In this chapter, I begin by providing a brief overview of characteristic elements of chaos and move to the larger domain of complexity theory and complex adaptive systems to provide a framework for the remainder of the thesis. Then, I shift to a discussion the development of recent writing process theories that have informed this case study in terms of research questions, methodologies, and analyses. Then, I discuss some of the connections between writing

theories, chaos, and complexity that informed my research design, especially as they appear in studies of artificial intelligence, materiality, and the digital divide.

Order out of Chaos

There is no definitive definition for chaos or complexity. Instead, in the literature related to these subjects, writers, scholars, and researchers describe chaos and complexity theory in terms of inherent descriptive characteristics of system behaviors typically explained with lengthy lists, examples, and metaphors. Historically, when scientists observed simple phenomena, they looked for simple causes. Similarly, scientists looked for complex explanations to explicate complex behavior. Chaos theory broke through these assumptions with the realization that simple deterministic systems could produce what looked like random behavior. Gleick cites that some physicists view chaos as a qualitative science of studying a process rather than a state: “[t]hey feel that they are turning back a trend in science toward reductionism, the analysis of systems in terms of their constituent parts: quarks, chromosomes, or neurons. They believe that they are looking for the whole” (5). As Nina Hall observes in her introduction to *The New Scientist’ Guide to Chaos*, “chaos theory depicts a universe that is deterministic, obeying the fundamental physical laws, but with a predisposition for disorder, complexity and unpredictability” (8). Harriett Hawkins cites Ian Percival for describing chaos as “persistent instability” (ix). A state of persistent instability could serve as an accurate description of many peoples’ writing processes, including my own.

In popular culture, chaos has typically had a negative connotation because it embodied that which was unpredictable, uncontrollable, and therefore destructive in

human life because it was irreducible, inexplicable, and volatile. Chaos, as I refer to it in this thesis, is not as it has often been defined in classical literature and popular culture hopeless randomness or chance. Instead, many chaos theorists do not perceive chaos as inherently evil or malevolent but necessary for creativity and the creation of order. As Bonnie Lenore Kyburz writes, “Chaos theory seeks to understand the complexity of the real world and its productive, reproductive, regenerative, and transformative power, not merely the closed world of Euclidean shapes, linear systems, and perfect forms” (511). This interest in the dialectic relationship between order and disorder predisposes chaos theory to have a wide-ranging influence in interdisciplinary research including such fields as nonlinear dynamics, irreversible thermodynamics, meteorology, and ecology. Now that science has been looking for chaos, it seems to be everywhere.

Throughout this thesis, I refer to deterministic chaos, which describes unstable and aperiodic behavior in deterministic nonlinear dynamical systems. A dynamic system includes the potential for producing a mathematical description of the instantaneous state of a physical system and a set of rules for transforming the current state description into a sketch of the system at a different time. The aspects of chaos that I have found to be most relevant throughout this study to understand the writing process have been the concepts associated with sensitive dependence on initial conditions, strange attractors, and recursive symmetry.

Sensitive Dependence on Initial Conditions

Chaos theorists are interested in systems that exhibit nonlinear behavior where sensitivity to initial conditions results in effects that are disproportionate to their causes.

The weather is a prime example of unpredictable behavior over time. Before chaos became a recognized field, MIT meteorologist Edward Lorenz discovered the butterfly effect and strange attractors in weather phenomena. The butterfly effect is a metaphor for understanding how even microscopic differences in initial conditions and uncontrollable events amplify into macroscopic magnitudes and global pattern changes. While the inability to identify all relevant initial conditions makes it impossible to predict behavior accurately, nonlinear dynamical systems follow definable rules. These phenomena thrive in deterministic chaos and perpetuate the possibility that small perturbations in a system, especially far from equilibrium, where many natural systems tend to survive, can cause unpredictable and dramatic qualitative changes.

Phase Space and Strange Attractors

Chaos theory emphasizes the hidden order that exists within chaotic systems. Despite chaos' unpredictable nature, modeling and visualizing chaotic behavior remains productive in gaining a fuller understanding of complex systems. Before I go any further, it is necessary to discuss a powerful heuristic modeling tool that allows us to visualize the behavior of a system as it changes over time—phase space. A phase-space is a representation of a system's activity over time represented in an abstract physical space with multiple dimensions. In phase space, the knowledge about a dynamical system, represented by the given properties, at a single instant in time collapses to a single point. That point embodies the dynamical system at that specific instant. At the next instant though, the system changes ever so slightly; therefore, the point moves.

Whereas random systems show no discernible pattern, chaotic systems inhabit a confined region and trace complex patterns. The phase space representation of a system may gravitate towards a point or area, remain there for some time, and then unpredictably to another basin of attraction. This phenomenon of chaos is distinct from absolute randomness because it represents deeply encoded structures called attractors. Attractors come in several types. Fixed-point attractors describe a system that always settles down into a single point and is completely predictable, such as a falling book. Periodic (or limit-cycle) attractors are repeating loops between states, such as the earth orbiting around the sun is or an undamped pendulum. Lorenz introduced the non-periodic attractor, which is known as the “strange attractor.” The strange attractor is strange because it is nonlinear while simultaneously forming a recognizable, but never identical, pattern over multiple iterations.

Recursive Symmetry

In chaos theory, self-similarity is symmetry across differing scales of distance. It implies recursion revealing a pattern inside of pattern inside of a pattern. These different scales reveal more of the complexity embedded within natural systems. Self-similarity is built into the technique of constructing the curves, like the replication of DNA, similar transformations repeat at smaller and larger scales. Self-similarity is an easily recognizable quality. Examples such as Cantor dust, the Koch curve, measuring the coastline of Britain, and the Menger sponge demonstrate the iteration of comparably complex details on every scale. The Mandelbrot set, discovered by Benoit Mandelbrot in 1980 for instance, is a set produced by the recursive application of a simple formula

whose input at any one stage is the output of the previous stage. This mathematical object consists of an infinite diversity of complex, irregular forms, produced by an extremely simple means.

In another demonstration of the importance of scale, Gleick describes physicist Mitchell Feigenbaum's habit of taking long walks and letting ideas flow through his mind. One day he passed some talking picnickers while observing their emotions, hand gestures, and reaching for food. As he walked farther away, Feigenbaum realized that the people were too small to distinguish and their words and gestures had lost all meaning, appearing disconnected, arbitrary, and random. He realized that scale and distance determines how people perceive and understand a phenomenon (Gleick 163). Hayles writes that fractal geometry brings classic assumptions about scale into question because, "measurements on scales of different lengths do not converge to a limit but continue to increase as measurement scales decrease" (12). In complex systems, similar patterns emerge at several scales and the meanings or understandings that come from examining a system often depends on the scale at which that system is observed and analyzed.

Moving Towards Complexity

Chaos is one category of nonlinear dynamics which could be considered a subsystem of complexity theory and nonlinear dynamics as a whole. Stanislaw Ulam said that calling chaos "nonlinear science" was like calling zoology "the study of non-elephant animals." In other words, chaos and complexity both share similar characteristics of nonlinear dynamics, but there are also several significant differences. Complexity theory is less concerned with establishing the inescapability of "determinate chaos" than with

emergence of order and self-organization from many independently functioning constituent elements in a complex adaptive system. Since scholars are still investigating both theories as to the boundaries, characteristics, and elements that distinguish themselves from one another, both may hold significant insights for understanding the writing process.

Describing Complexity

It should not be surprising that there is no simple definition of complexity. Classical science and philosophy, at least since the medieval era, tried to understand the universe by reducing complexity to simplicity using methods such as Occam's razor and reductive analyses. The desire for simplicity has long inspired efforts to explain the world in terms of simple systems that function smoothly and simple laws that are reducible to simple equations. It is unlikely that a topic as complicated as complexity will conform to a concise definition. Paul Cilliers states that complexity is often so difficult for us to comprehend that there still is not at least a working definition of what complexity might mean. "There is neither something at a level below (a source), not at a level above (a meta description), capable of capturing the essence of complexity," (Cilliers 3). In his recent book, *Emergence: From Chaos to Order*, Holland explains that complexity is difficult to define because of the concept of emergence. According to Holland, "Emergence...occurs only when the activities of the parts do not simply sum to give the activity of the whole" (14). Holland does not attempt to offer any other definition except to say that "we will not understand life and living organisms until we understand emergence" (1).

Paul Cilliers, John Holland, and Mark Taylor provide personal lists of the essential characteristics of complex systems. Each list includes similar elements from the other lists while emphasizing dissimilar distinctions. Each scholar tends to emphasize different aspects of complex systems to explain their understandings of complexity. Cilliers argues that complex systems have characteristics that are not determined merely by the perspective of the observer. Holland's primary focus with complex systems is the concept of emergent behavior and modeling system behavior through metaphors and examples. The diversity of these descriptions indicates that complexity is a growing and unstable field of research that has yet to be clearly defined. Waldrop explains that complexity is, "a subject that's still so new and so wide-ranging that nobody knows quite how to define it, or even where its boundaries lie. But then, that's the whole point" (9). The uncertainty of definition forces us to rely on partial descriptions, which in turn rely heavily on context. Although the field remains uncharted, I provide some landmarks along with some requirements for studying the terrain. Therefore, this summary mainly suggests loci for augmented attention.

Similar to the ubiquity of chaos, we are embedded in nonlinear complex systems. Once we understand that we ourselves are made of multiple complex systems and we live in multiple complex systems at several scales, it is difficult not to notice the complexity surrounding everyday situations. Complexity pervades human experience from our own anatomical structure in the multi-layered systems which keep us alive to economic stock markets where millions of individual decisions to buy or not to buy can reinforce each other, creating a boom or a recession, generating an economic climate that shape the very buying decisions that produced the present economic conditions.

Emergence and complex adaptive systems in ant colonies, networks of neurons, animal populations, the Internet, and human language are just a few more examples of the collective interdependence of living systems. Multiple threads of interdependently acting agents are intricately interwoven to create the complex systems in life, their strands can be distinguished and analyzed in ways that illuminate contemporary experience. Complexity theorists aim to identify common characteristics of diverse complex systems and to determine the principles and laws by which they operate.

Complicated versus Complex

The distinction between a simple and a complex system often becomes a function of the type of description and the distance of analyses used to describe the system. Cilliers sketches the characteristics of complex systems by discussing important distinctions between “simple” and “complex” and “complicated” and “complex.” Cilliers states that, “[m]any systems appear simple, but reveal remarkable complexity when examined closely (e.g. a leaf)” (2), and “[o]thers appear complex, but can be described simply, e.g. some machines, such as the internal combustion engine” (2). In describing the differences between complicated systems and complex systems, Cilliers uses an example of a CD player, a snowflake, or the Mandelbrot set as something that is complicated but still can be given an exact description. Simple and complicated systems can be analyzed reductively because they are linear; therefore, the whole is equivalent to the sum of the components. Unlike complicated systems, such as a clock, airplane, or internal combustion engine, which can be understood in terms of their component parts, complex systems are unpredictable, self-organizing, adaptive, and dynamic creating a

discontinuity between the parts of the system and the resulting evolving outcomes. On the other hand, complex systems are often, “associated with living things: a bacterium, the brain, social systems, language”(3), whereby the complexity results from the intricate relationships between those components creating emergent nonlinear behavior; therefore, the whole is greater than the sum of these elements. What distinguishes a complex system from a merely complicated one is that some behaviors and patterns evolve and emerge in complex adaptive systems as a result of the patterns of interactions between elements.

Describing Complex Adaptive Systems

Complex systems are open systems that exchange energy, matter, and information across system boundaries and with their environments. Often the boundaries between the inside and outside the system are problematic and ambiguous. The decision is usually based on the observer’s interests, needs, and prejudices rather than any intrinsic property of the system itself. Boundaries are also nearly inextricable because complex adaptive systems are entrenched with other complex systems at multiple levels of scale. For example, an economy is made up of businesses and organizations, which are made up of people, who are systems of organs controlled by their nervous systems and endocrine systems, which are made up of cells, and so on. All of these “agents” within their respective systems at each level in the hierarchy, are complex adaptive systems themselves. The significance for this discussion is that information from the environment has a direct, though non-determinate, influence on the system. In other words, the environment causes certain changes in the system, but it does not solely determine the nature of these changes (Cilliers 125). The state of the system at any given instant is the

result of conditions of the environment, the history of the system, and the reciprocal influences that the system must have on its environment in order to survive.

Information from the environment reacts in a nonlinear way with information already stored in the system. Each complex system filters incoming information considering the history of the system in such a way that it incorporates new aspects, but resists unnecessary fluctuations. To be able to survive in its environment, the system must have some form of resistance to change as well as some mechanism for comparing different conditions in order to determine whether there is enough change or difference to justify a response. Both these attributes reveal a complex system's need for a type of memory because without resistance to change, a memory is useless.

The importance of memory also reveals that complex systems have a developmental history. Cilliers clarifies the significance of a complex system's history when he writes, “[n]o complex system, whether biological or social, can be understood without considering its history. Two similar systems placed in identical situations may respond in vastly different ways if they have different histories” (107). Even a small change in circumstances can lead to large deviations in the future. The history of a system influences the development of the structure of the system and is therefore important to understanding the system. If the self-organizing capabilities of such a system are adequate, it will then learn to cope with a changing environment.

A complex adaptive system receives a stream of data about itself and its surroundings. In that stream, it identifies particular regularities and compresses them into a concise “schema,” one of many possible ones related by mutation or substitution. In the presence of further data from the stream, the schema can supply descriptions of certain

aspects of the real world, predictions of events that are to happen in the real world, and prescriptions for behavior of the complex adaptive system in the real world. In all these cases, there are real world consequences: the descriptions can turn out to be more accurate or less accurate, the predictions can turn out to be more reliable or less reliable, and the prescriptions for behavior can turn out to lead to favorable or unfavorable outcomes. All these consequences then feed back to exert “selection pressures” on the competition among various schemata, so that there is a strong tendency for more successful schemata to survive and for less successful ones to disappear or at least to be demoted in some sense.

Neural nets and connectionism, disciplines associated with cognition and artificial intelligence, suggest how many independent interacting agents behaving according to simple rules can express “intelligent” behavior in much the same way that an any colony or flock of birds organize without a central authority. In the brain, when a pulse arrives at a synapse, it causes the release of biochemicals called transmitters, which diffuse across the synaptic gap. The release of chemicals at a synapse can be more or less efficient, depending on the past history of pulses passing across the gap—much as exercise can improve muscle efficiency, while disuse can decrease it (Holland 85). Because the actions of the individual agents are conditioned by the immediate surroundings (other agents and objects in the environment), there is no easy way to predict the overall behavior by looking at the behavior of an “average” individual (Holland 118).

Similarly, writing is a practice that writers must continually practice in order to improve.

Complex systems have the ability to learn from their environments in the sense that the rich interactions among many elements can demonstrate intelligent behavior.

Complexity theory reveals that collections of intelligent agents are neither necessary nor sufficient for intelligent behavior of the whole system. The classic description of agent-based emergence is Douglas Hofstadter's metaphor of the ant colony. Despite the limited repertoire of the individual agents—the ants—the colony exhibits remarkable flexibility in probing and exploiting its surroundings. Somehow, the simple laws of the agents generate an emergent behavior far beyond their individual capacities. Each agent functions by processing material, energy, or information to produce some action, which usually involves transferring received material, energy, or information. More generally, we can describe the agent as processing an input to produce an output. The input state is determined by the immediate environment of the agent, and the output state determines the agent's effect on its immediate environment.

This rich combination of local interactions is why complex systems are irreducible. The network cannot be analyzed as a collection of its basic elements because too much of the relational behavior from the system is lost when it is broken into individual agents. Typically, the relationships between elements in a complex system are short in their range, that is information is normally exchanged among local neighbours. The richness of the connections means that communications will pass across the system but will probably be modified on the way. If connectedness among species within the system is low, then the effects of the initial perturbations will soon disappear. This is when the system is near the frozen state. With high connectivity, any single change is likely to propagate hectically throughout the system, with many large avalanches. This is the chaotic state. At the edge of chaos, some perturbations provoke little or no ripples

throughout the system while others trigger avalanches equivalent to mass extinctions (Lewin 62).

Cilliers clarifies that it is not that long distance communication is impossible, but it requires much more energy from the system and is therefore less probable. Individual agents typically exhibit a limited knowledge of local interactions while remaining ignorant of larger global patterns. Therefore, there is no single agent within the system that can comprehend the system as a whole or autonomously control the system. However, because the system is networked, fragments of information are distributed throughout recursive loops in the system.

Both negative and positive feedback are key ingredients of complex systems because these systems operate far from equilibrium and nonlinear behavior depends on the recursive transfer of information. The effects of an agent's actions are fed back to the agent and this, in turn, affects the way the agent behaves in the future. Recursive positive and negative feedback generates the systems' overall behavior. As a result of these feedback mechanisms, complex systems, like chaotic systems, also exhibit attractors of behavior. However, attractors in complex systems are not static. Because complex systems are open systems, attractors will change and dynamical possibilities will change as the environment changes. The environment may reduce the stability of some attractors and advance the stability of others (Lewin 73). To interpret the information from the environment, there must be a network of connections relaying information from the environment to the rest of the system and back again. As connections or interconnections proliferate, complexity expands and, correlatively, information increases. Complex

systems must be able to adapt to changes in the environment; therefore, external conditions must influence their internal structure.

The Edge of Chaos

According to complexity theorists, all significant change takes place between too much and too little order, exactly where complexity flourishes. When there is too much order, systems freeze and cannot change, and when there is too little order, systems disintegrate and can no longer function. Instead, all of these complex systems have the ability to bring order and chaos into a special kind of balance. The edge of chaos is where life has enough stability to sustain itself and enough creativity to deserve the name of life. Far from equilibrium, systems change in surprising but not necessarily random ways. The idea that systems exist far from equilibrium is like a rock perched at the edge of a cliff; it is in position to make the greatest amount of change in the system with little required additional energy to make that change. The edge of chaos is the constantly shifting battle zone between stagnation and anarchy, the one place where a complex system can be spontaneous, adaptive, and alive.

Physicist Per Bak provides a clear example of a system at the edge of chaos. He describes the dynamics of this critical point like a sand pile to which individual grains of sand are gradually added. As the grains accumulate, the pile approaches a critical state in which the addition of one more grain of sand can settle into place or unleash an avalanche in the pile as a whole. Bak argues that complex behavior in nature,

reflects the tendency of large systems with many components to evolve into a poised, “critical” state, way out of balance, where minor

disturbances may lead to events called avalanches, of all sizes. Most of the changes take place through catastrophic events rather than by following a smooth gradual path. The evolution of this very delicate state occurs without design from any outside agent. The state is established solely because of the dynamical interactions among individual elements of the system: the critical state is self-organized. Self-organized criticality is so far the only known general mechanism of complexity. (1-2)

At this critical point, the effect of individual events is unpredictable. While it is possible to know that at some point an avalanche will occur, it is never possible to be sure which particular grain of sand will tip the balance and thereby upset the equilibrium.

The theory of self-organized criticality tells us that a self-organizing system will try to balance itself at a critical point between rigid order and chaos. It will try to optimize the number and relationships among attractors without becoming unstable. A system that only behaves chaotically is useless. On the other hand, a system that is too rigid is also disadvantageous because the system will not allow adaptation and therefore the system will probably not survive in a changing environment. If each state of the system requires a strong, stable attractor, most of the resources of the system will be used in maintaining the structure, and the capacity of the system for adaptation will be severely limited. Furthermore, movement from one stable state to another will require large amounts of energy (Cilliers 97). As a result, the system will respond slowly to environmental changes. However, with the system poised at the edge of chaos, the number of stable states will not only be optimized, but the system will also be able to change its state with the least amount of effort. If life does thrive at the edge of chaos,

then it should be possible to trace characteristics of complexity in previous research applied to any discipline—including composition.

Previous Writing Process Research

The physical environment of the writing classroom has dramatically evolved since the eighteenth century in terms of pedagogies, technologies, and demographics. Research in the process writers experience to produce a quality text has been a primary focus in composition studies for over the past thirty years. The hope, of course, was that by learning more about how people actually write, scholars could devise increasingly accurate theoretical models of the composing process and educators could improve pedagogical strategies. One of the most evident findings of this research is that not all effective writers write alike. Although there are certainly common strategies and even some general approaches, epistemologies, and theories of writing, a particular writer's process is unique. Writing processes are nearly as individual as personal handwriting, fingerprints, or DNA. Individual learning styles, domain knowledge, familiarity with a particular genre, interest in the subject, teacher's pedagogy, available resources, level of education, amount of practice in developing writing skills and a wide variety of other factors can shape how writers generate ideas and collection information.

As expected, academics have proposed many different theories, models, and practices debating the individualistic nature of writing and criticized other explanations. This brief overview will describe some of the relevant previous research into the writing process that has influenced my research design. I do not intend to provide a comprehensive treatment of writing theory, but my purpose is to provide some of the basic distinctions between selected contemporary writing theorists representing the

current-traditional, expressivist, social constructivist, and cognitive perspectives. What follows is more of a dialogue among scholars concerning the writing process and points where many of these earlier studies alluded to characteristics of complex adaptive systems.

To understand writing theory debates, it is useful to consider the rhetorical triangle as positioning the reader, the author, and the text at each point of the triangle resting within a historical context. Theorists examine the elements of this triangle and associate different interpretations, values, and importance with each part of the triangle to describe the truth, or the lack thereof, about the nature of reality, identity, and meaning. Parallel to Bolter and Grusin's portrayal of remediation, each new theory is justified because it fills a lack or repairs a fault in its predecessors, because it attempts to realize the unfulfilled promises of older theories to explain human experience, identity, and purpose in life. However, Wallace Martin argues that the humanities differ from progressive sciences because it has never been able to discard old theories because they are demonstrably less adequate than those that replace them. Martin describes literary study as "a cumulative discipline to which new knowledge is added, but unfashionable ideas that have long been dormant may at any time prove their relevance to new critical concerns of creative methods" (30). Each theory provides a different way of examining many of the same issues by asking different questions or emphasizing different parts of the rhetorical triangle. In the same way, this study is an attempt to examine the writing process through another lens to explore potentially generative insights into how students write. Martin summarized all composition theories well when he wrote, "If there is a

moral to be drawn from this inconclusive tale, it is that theories are as revealing, misleading, reductive, or constructive as the people who create and use them” (106).

Current-Traditionalism

Traditionally, the most prevalent pedagogical standard in America has been the current-traditional paradigm based around the teacher-centered lecture model in which the instructor directs writing activities from the front of the classroom, and the students sit passively in orderly rows facing the instructor. The lecture mode of teaching, an instructional approach which advocates “information transfusion” rather than “information creation,” emphasizes the role of the instructor as the unquestionable source of knowledge, power, values (in the form of grades), and proper behavior. In the current-traditional model, knowledge is “banked,” in the Freiran sense, and students have few opportunities to experience the creation of knowledge as is possible under a process-centered pedagogy. It becomes readily apparent that this structure supports Berlin’s argument that writing teachers present which forms of knowledge and reality are acceptable and which ones are not.

Inherent in current-traditional epistemology is the Romantic assumption that good writers are born with a natural genius and the best that everyone else can hope for is to follow the “rules.” Before the 1970s, the current-traditional method of teaching writing tended to focus on grammar, punctuation, spelling, imitating “great” writing, and following formal structures and patterns. This model privileged a very small number of writing genre like expository, descriptive, narrative, and argument report writing. In discussing current-traditional pedagogy, Berlin writes, “The world readily surrenders its

meaning to anyone who observes it properly, and no operation of the mind—logical or otherwise—is needed to arrive at truth” (770). In this sense, Berlin asserts that composition instruction is forced into focusing, “on discourse that appeals to the understanding—exposition, narration, description, and argumentation (distinct now from persuasion)...college rhetoric is to be concerned solely with the communication of truth that is certain and empirically verifiable—in other words, not probabilistic” (770).

Alvin Toffler, in his foreword to Ilya Prigogine and Isabelle Stengers’ *Order Out of Chaos: Man’s New Dialogue with Nature*, observes that we have become experts at “dissection: the split-up of problems into their smallest possible components. We are good at it. So good, we often forget to put the pieces back together again” (xi). Atomic structure appears, at different points on a historical timeline, as a conceptualization of order; however, the atom—knowledge of the atom—appears differently at each of these points. Similarly, as composition has emerged, various theories have been generally accepted (or not) at different points in the discipline’s history, creating pockets of order or knowledge within a diverse and often contested intellectual terrain. In much of the same way that particle physics has explored the atom and increasing our knowledge about the smaller and smaller parts that constitute matter, linguists have dissected language and writing into its atomic parts of signs, signifiers, phonemes, graphemes, lexemes, and morphemes. Using similar reductive approaches, composition instruction has sustained a long history relying on the current-traditional paradigm and “back-to-basics” grammar instruction of writing. However, research conducted since the early 1960s (such as Braddock, O’Hare, Hillocks, and Elley) shows that grammar instruction that is separate from writing instruction does not improve students’ writing competence

or effectiveness. Empirical researchers have accumulated a substantial body of evidence suggesting that teaching grammar does not improve students' writing abilities. George Hillocks Jr. in *Research on Written Composition*, a book-length survey of recent empirical studies in composition, concludes:

The study of traditional school grammar (i.e., the definition of parts of speech, the parsing of sentences, etc.) has no effect on raising the quality of student writing. Every other focus of instruction examined in this review is stronger. Taught in certain ways, grammar and mechanics instruction has a deleterious effect on student writing. In some studies a heavy emphasis on mechanics and usage (e.g., marking every error) resulted in significant losses in overall quality (248).

Clearly, it is not necessary to understand the interactions of morphemes and phonemes in order to produce quality texts.

Current-traditionalism emphasizes dissection of a whole. Students learn to examine and re-examine each part of the writing process in order to understand the components of writing. In this examination, however, the fact that writing is a whole, composed of mutually dependent and inseparable processes, seems to get lost. In current-traditionalist classrooms, students learn that writing remains a series of discrete steps, all of which lead to the creation of a text, but none of which seem to interact with the others. Current traditionalism also isolates the stages of writing; it isolates both writer and reader during the entire writing process; and its emphasis upon sentence-level errors overshadows any concern for the essay written as a whole as the result of a coherent process.

Interactions within the current-traditionalist writing classroom tend to remain hierarchical; they emanate from the instructor, to the student, and back to the instructor. There is very little opportunity for peer feedback or collaborative work because of the strong value of individual work, which still pervades academic institutions today. Therefore, current-traditionalism does not allow students to realize nor to benefit from feedback inherent within the student-centered writing classroom that is necessary for the growth in student writers and their documents. Current-traditionalists limit student writers from recognizing the value of their interactions by limiting valued interactions to teacher-student communications such as grades and written or spoken comments. In current-traditional classrooms, students ultimately learn that writing is not so much to be read and enjoyed as to be evaluated. When considering the potential growth, creativity, and learning that naturally occurs within the dynamics and open information flow in complex systems, the restrictions within the current-traditional model, relying on its Romantic assumptions, effectively constructs and reinforces its own self-fulfilling prophesy.

The evolution and growth of any interactive community or system depends upon the recognition of the system's elements of their roles as interactive and mutually dependent members of that system. Resulting from the hierarchical organization and strict structure of the current-traditional paradigm, these classrooms do not take advantage of the creative, generative, and powerful forces associated with learning and complex systems. The current-traditional paradigm most likely fits into Wolfram's class one or class two behaviors¹, where the rules are strict and the evolution of the student's writing will either maintain a homogeneous state or become a periodic oscillator only

capable of two functions. As will be discussed later, static equilibrium states in complex systems are synonymous with death. Obviously, this is unacceptable considering the diversity of audiences, contexts, and subjects for which most students are required to write. Emerging simultaneously with open admission policies at American colleges and universities, researchers sought to understand the writing process in order to develop pedagogical practices that would improve writing instruction for a changing demographic student population. If the writing process truly is a complex recursive process, then the current-traditional paradigm acts in opposition to the nature of writing and creates more barriers to help students learn to write more effectively than it enables students to succeed.

Writing as a Process

In reaction to current-traditional rhetoric, process-oriented pedagogy began to develop in the late 1960s and 1970s. Whereas current-traditional rhetoric emphasized the author's polished text, process allowed for stages of feedback and revision. Process became an important psychological model to define in writing. Process theories explored the connections between experience and emotion and their communication through language. The process method also focuses attention on the student as a writer and enables the teacher and the student's peers to assist in the practice of writing. Student-teacher conferences, collaborative writing, peer consulting, and the importance of several drafts all receive significant attention through process-oriented pedagogy.

Researchers investigating the composing process have primarily used ethnographies and case studies because of the complex, dynamic, and multivariable

nature of writing, but they have also proposed various models and explanations for that process. Emig's 1971 case study was influential in gaining momentum for the process movement. By studying eight twelfth graders as they "composed aloud," Emig became one of the first researchers in the field to employ the case study method. Following Emig, Flower and Hayes conducted research using protocol analysis to understand college students' composing processes. Linda Flower and John Hayes did their groundbreaking work in the 1970s and 1980s elucidating "A Cognitive Theory of Writing," which characterizes writing as a kind of "problem-solving" activity in which writers develop goals and plans to attempt to solve problems that the writing task presents. This model provided and explained a generic writing process used by both expert and novice writers to differing levels of effectiveness. The Flower-Hayes model introduced cognitive theories from psychology into composition, foregrounding the psychological dimension of writing. In their cognitive models of composing processes, writers draw on long-term and short-term memory as they make plans, solve problems, and develop goals and strategies for writing and revising text. Flower and Hayes chose to describe writing in terms of three general activities: planning, translating, and reviewing. They saw the activity of planning as consisting of three sub-activities (planning, generating and revising) which are used repeatedly at different levels (word, phrase, sentence, etc.) and at different times. It is important to note that Flower and Hayes conclude that these three stages occur not as separate or orderly steps, but recursively as part of a highly complex cognitive process that is tacit in nature.

Cognitive models tend to categorize events and activities into separate interacting units and processes as two groups of researchers, Neuwirth, Kaufer, Chimera, and

Gillespie and Smith, Weiss, and Ferguson, both identified in 1987. Neuwirth et al. identified four activities central to the writing process: acquiring knowledge, exploring different perspectives, developing and identifying structure, and selecting and arranging content. They also suggested that the task in expository writing is to transform a network representation of ideas into linear sequences of words such as phrases, clauses, and sentences. On the other hand, Smith et al. saw writing as consisting of four modes: prewriting, organizing, writing, and editing. To them, the process of writing consists of using each of these modes to transform or change the work produced in the preceding mode. While cognitive models integrate psychology and provide a simple analogy to understand writing, the weakness of most cognitive models was that they were relatively reductive.

Cognitive models, based on research that is narrow in scope and method, do not account for the complexity or dynamism that social and cultural influences have on the writing process. Responding to this deficiency, authors such as Bartholomae, Berlin, Bizzell, and Bruffee presented models that included social constructivism. Social constructivism assumes that identity and reality are based on shared language and maintains that writing is a social and cultural activity. Based primarily on the social interactions between “discourse communities,”—groups of individuals who share specific and unique values and language patterns—this type of pedagogy encourages social exchanges as the basis of writing and learning. Part of the need for this shift was to help account for and aid the students who still failed to engage with writing tasks despite receiving specific strategies and heuristics in planning, producing, and revising their texts. As a theoretical result, students become more active in formulating and remodeling

both educational and social structures. In this context, process has become “liberatory pedagogy” which allows for the examination, reevaluation, and restructuring of not only rhetoric but also the social structure that produces it. Despite critiques from social constructivists, cognitive scientists continued to hone their models of writing.

In 1986, Carl Bereiter and Marlene Scardamalia built from the work of Flower and Hayes and suggested a slightly different theory of writing in which there were two distinct processes involved depending on the complexity of the writing task: “knowledge-telling” and “knowledge-transforming.” In knowledge-telling, the writers access topic and genre knowledge. Knowledge-telling typically involves a simple repetition of facts and checking that what writers are writing is appropriate. Knowledge-transforming is more complicated by requiring a metacognitive awareness because it requires writers to “transform” their content, or topic knowledge, into an appropriate form, which will solve the “problem” that the writing task poses for them (294). Based on their understanding that writers could achieve this kind of awareness, which they term an “executive routine,” Bereiter and Scardamalia make a case for teaching writing as a problem-formulating and problem-solving activity. Their research found that novice writers were more likely to use “knowledge-telling” strategies and less likely to use “knowledge-transforming” processes.

Both Donald Murray and especially Peter Elbow question the intrinsic value of the kind of typical academic writing that relies simply on “knowledge telling.” As the idea of process began to grow, Donald Murray was among the first to articulate the then-radical position that writing should be taught as a process of discovery through language. Theorists such as Elbow, Murray, and Ken Macrorie see writing as a process of self-

investigation and discovery of a writer's authentic voice. Murray and Elbow's contentions are generally based on the notion of writing as a creative personal experience that arises out of the human imagination. Murray goes so far as to state that "instead of teaching finished writing, we should teach unfinished writing, and glory in its unfinishedness," and he proposes a structure for pedagogical heuristics that incorporate his approach (3). The metaphor of writing as organic growth, promoted by Peter Elbow, has significantly influenced contemporary conceptions of writing. Expressivism when examined with comparisons to complex systems would most likely tend towards embracing chaos by encouraging freedom, random stream-of-consciousness free writing, brainstorming, and capitalizing on the generative and inventive characteristics of imagination and unpredictable tangents, connections, and energy from one thought to the next.

James Kinneavy objects to the practice of free writing as he writes, "Professional writers don't just sit down and begin an exercise in free-writing," to emphasize that great writing takes a lot of research, time, and practice to perfect (2). Berlin also criticized this expressionist notion of process for its epistemological position that truth resides within the individual as opposed to, as he proposes with New Rhetoric, the dynamic nature of truth that emerges from the dialectic interaction between the writer, audience, language, and reality (774). Social constructivists vigorously argue that the social, cultural, and historical context create, maintain, and feedback into the nature of language and writing. Therefore, any theory that ignores or negates these influences fails to represent accurately the competing and adaptive oppositional forces that exist in reality.

The very influential theorizing of Mikhail Bakhtin helped to move the cognitive models into considering the significance of social and contextual factors. Bakhtin's notion of *centripetal* and *centrifugal* forces helps to expose the complexity writers experience as they compose a text. Centripetal forces attempt to unify discourse, much like the dominant or normative discourse of the institution attempts to stabilize language. Conversely, centrifugal forces attempt to stretch the boundaries of language, much like the type of discourse that students bring with them to the academy. These centrifugal forces are what Bakhtin refers to as heteroglossia, and they are always contending with centripetal forces.

Heteroglossia embodies complex and rich interactions, drawing on more than just language differences but on differences in socioeconomic background and cultural stratification. Bakhtin defines heteroglossia by writing:

At any given moment of its evolution, language is stratified not only into linguistic dialects in the strict sense of the word (according to formal linguistic markers, especially phonetic), but also—and for us this the essential point—into languages that are socio-ideological: languages of social groups, “professional” and “generic” languages, languages of generations and so forth. From this point of view, literary language itself is only one of these heteroglot languages—and in its turn is also stratified into language (generic, period-bound and others). And this stratification and heteroglossia, once realized, is not only a static invariant of linguistic life, but also what insures its dynamics: stratification and heteroglossia widen and deepen as long as language is alive and developing. Alongside

the centripetal forces, the centrifugal forces of language carry on their uninterrupted work, alongside verbal-ideology centralization and unification, the uninterrupted processes of decentralization and disunification go forward. (75)

The principal unit of heteroglossic dialogue in Bakhtin's own terms is the utterance. The utterance is a thought that is given voice in either writing or speaking. It thrives in dialogue where it is social like language, but also has a concrete meaning. Heteroglossia is also understood as many-voicedness, but it goes beyond the notion of many voices, offering a much broader view of multiple-voices. That is, as stated in Bakhtin's description of heteroglossia, it encompasses not only these many voices but also the perspectives from which these voices originate. Heteroglossia is what influences voice and maintains it.

The words, thoughts, ideas of this text are never precisely my own; they are always borrowed rather than possessed. I do not claim individual ownership for the ideas presented throughout; however, I have attempted to compile and synthesize ideas in a way that will be generative in providing a way to see the connections or disconnections between complexity theory and the writing process. The flux of information rushing through my mind as well as my body existed before me and will continue to flow long after I am gone. In a sense, all writing is ghostwriting. Countless phantoms and fragments of competing memes, to borrow Richard Dawkin's phrase, haunt this work, like all others. I am familiar with some of these voices, ideas, and connections, while others remain strangers. I cite numerous sources for direct attribution, but others I do not. Not because I have something to hide, but in a Bakhtinian polyphonous sense, all thoughts

interact through a dialogue over time and I cannot ascertain their origin. Thinking is impossible without tacit or manifest conversations with the living as well as with the dead through their writing. Since thinking is a complex process in which images, concepts, and schemata are always struggling to adapt to each other, the pieces of the puzzle form networks of relationships in which changes in a particular time or place reverberate throughout the web. As vibrations become waves, webs become less and less stable. It is the social and environmental intersection and interaction of these centripetal and centrifugal forces, mirroring similar interactions between order and disorder, which create and maintain the complexity of the writing process. Viewing composition from the edge of chaos, I want to avoid any association with solipsism while exploring the generative potential insights that complexity can offer to composition.

Process-centered epistemology serves as an umbrella model that focuses on the composing process rather than the locations of truth. The process-centered model allows truth to exist outside of the text; meaning an individual finds truth through a process whether or not that truth comes from within the individual, through the senses, in “conformance with the rules of logic” (Berlin 767), or a “process involving the interaction of opposing elements” (Berlin 774). As Berlin points out in discussing Neo-Platonic, Neo-Aristotelian, and the New Rhetoricians, teaching “students a notion of the composing process will enable them to become effective persons as they become effective writers” (777). In this sense, process pedagogy shifted the focus from questions and locations of truth to understanding the writer’s experiences and questions of becoming rather than being.

In 1982, process-oriented research persuaded Maxine Hairston to argue that the process movement represented the onset of a paradigm shift in the field—shifting from the current-traditional and product-oriented model to process-oriented. Despite Hairston’s call for revolution, the writing process attracted its share of critics. Berlin argued that “Everyone teaches the process of writing, but everyone does not teach the *same* process” (777). In 1996, Crowley further contested the argument that the process movement signified a paradigm shift or a revolution because, she argued, current-traditional rhetoric still holds significant power in contemporary writing instruction. Even the methodology in process research came under scrutiny because composing aloud was considered unnatural and the context involved in a case study was artificially created. Moves to integrate the impact of environment and social context research into the cognitive models of writing processes resulted in “social-cognitive” models of writing. In 1996, Hayes himself revised the model he and Flower articulated in order to account for factors such as the social and physical environment and well as motivation and affect. In “Competing Theories of Process: A Critique and A Proposal,” Faigley outlines a tripartite model that reflects three distinctive approaches: expressive, cognitive, and social. While Faigley largely views the cognitive and the social perspectives much the same as Bizzell does the inner and the outer directed theorists, Faigley’s model includes a distinct expressive approach, which draws on the Romantic tradition and emphasizes authentic voice as a major shaping force.

In addition to the cognitivist discussion of process, Murray discusses the importance of creativity and unpredictability in the writing process. Murray reveals his thoughts on teaching the writing process by writing:

It is the process of discovery through language. It is the process of exploration of what we know and what we feel about what we know through language. It is the process of using language to learn about our world, to evaluate what we learn about our world, to communicate what we learn about our world. (4)

Murray's comments on process certainly reflect a much more expressive perspective than Emig's interest in process dealing with actuality—the difference even resounds in the language these two scholars use to describe the writing process. Thus, approaching writing from a process-centered epistemological standpoint can be beneficial because it allows some epistemological space to navigate the complexity.

What is appealing about process-centered theory is its ability to traverse epistemological boundaries, yet we must not forget that process writing finds its roots in cognitivist theories of writing. Notably, Janet Emig's work delves into the many processes that constitute thinking, learning, and language, foregrounding the process of writing and its relationship to these processes. Emig writes: "What is striking about writing as a process is that, by its very nature, all three ways of dealing with actuality [learning by doing, by depiction in an image, and by restatement in words] are simultaneously or almost simultaneously deployed" (10). At the same time compositionists were discovering interactions between elements of the writing process, a small group of scientists were observing the similar phenomena involving synchronicity in complex systems.

As this discussion suggests, theorists and researchers have described writing as a recursive, complex, and self-organizing process, but until the development of chaos and

complexity theory, there have not been the metaphors or examples developed through, what Hayes would call, the cultural matrix to have a way to think about writing in this way. Writing is a nonlinear process. Writers almost never continue through their texts in a formulaic process using the same pattern, method, and amounts of time, energy, and motivation for every piece of writing or even similar genres of writing. Writers constantly move from one part of the process to another, sometimes generating text, sometimes revising, sometimes pausing to generate new ideas, and sometimes correcting mistakes. Typically, writers move back and forth through their text and through their ideas, at one point taking time to rethink their overall approach in light of feedback from other people, reconsiderations in terms of diction, audience, or rhetorical techniques and literary devices. Writers employ a variety of strategies as they engage in writing processes. Writers will attempt free writing, brainstorming, walking around, outline, listening to music, getting something to eat or drink, etc. For these reasons, scholars have attempted many models have been proposals, but all have been criticized for their inaccuracies, inadequacies, and misrepresentations.

Although the details of these models differ, they have much in common. All of them suggest that writing involves a number of distinct activities that interact on different levels of scale, through iterative, recursive, and interconnected ways. An important point for consideration is that no one ever learns to write by first learning Flower and Hayes' model, or any other model, of the writing process, nor was that model ever designed to be such a complete pedagogical tool that it would guarantee effective pedagogy. As Mark Taylor argues, there cannot be a perfect model because, "such a model would have the same drawbacks as a map as large and detailed as the city it represents, a map depicting

every park, every street, every building, every tree, every pothole, every inhabitant, and every map. Were such a map possible, its specificity would defeat its purpose: to generalize and abstract” (278). All models are limited in their representations of reality and even if there were a “perfect” model, it would not perfectly represent reality.

Composition Connections to Chaos and Complexity

The act of writing has long been considered a recursive process. With the advent of incorporating technology into classrooms to facilitate and improve classroom composition courses, it behooves administrators and educators to understand the act of writing in these new environments, and how, or if, these new tools such as the networked computer classroom, Internet, e-mail, online discussion forums, access to online databases, and writing center resources improve or enhance the composition processes and products students produce. Although not directly recognizing “chaos” in their work, Janet Emig, Linda Flower and John Hayes, and Andrea Lundsford, and others have attempted to get at notions of writing as nonlinear and dynamic processes.

Scholars have used the metaphor of chaos to describe student writing for a long time, but it has typically been used in the sense that the written product is ineffective, unproductive, confusing, unpredictable, or lacking in several areas. On the other hand, chaos can be generative in the ways in which it allows for creativity and surprising insight. Typically, chaos has been associated with the noise from which good writers are able to filter out the information and present a logical argument or presentation in an orderly fashion. However, noise and information are inextricably linked. There cannot be

one without the other, and often it is a matter of interpretation, conventions, or subjective values that decide what is to be considered noise and what provides valuable information.

With the development of chaos and complexity theory, Margaret Syverson, Marilyn Cooper, and Martin Nystrand have supported an ecological framework for understanding the writing process. In what Margaret Syverson refers to as the ecological system of writing, she describes complexity as: “a network of independent agents—people, atoms, neurons, or molecules, for instance—act and interact in parallel with each other, simultaneously reacting to and co-constructing their own environment” (Syverson 3). Syverson proposes that the four emerging aspects distribution, emergence, embodiment, and enaction of composition operate within five dimensions of cognition to include physical-material, social, psychological, spatial, and temporal. Syverson claims that few researchers have investigated the influence of the physical-material dimension on the writing process. Consequently, I have attempted to focus on the physical aspects of the natural writing environment when designing the methodology for this case study.

Cooper’s article on the ecology of writing was a counter response to the socio-cognitive models discussed earlier and a critique of the notion of the solitary author discovering and communicating truth through cognitive awareness. Aligning herself with the social constructivists, Cooper suggests that the process of composition is an ecological activity where the writer continually engaged multiple socially constructed systems. Cooper argues that an ecological perspective includes much more than the writers and their immediate context. “An ecologist explores how writers interact to form systems; all the characteristics of any individual writers or piece of writing both determine and are determined by the characteristics of all the other writers and writings in

the systems” (368). Through classroom observations and interviews, I attempt to capture the ecology of three student writers’ social systems and to understand how these social dynamics influenced their writing.

Nystrand argues that process pedagogy requires teachers to develop sophisticated understandings of epistemologies and the role of language to develop effective pedagogical practices that correspond to those sources of knowledge that shape and maintain the classroom epistemology (491). However, Nystrand explicitly describes through a case study how even an excellent teacher can encounter unexpected difficulties from competing demands and interrelationships, which can ultimately inhibit student writing practices. Nystrand’s research prepared me to be aware that although I was going to be observing an experienced composition teacher’s classroom, the chaos and complexity of any classroom can create unexpected challenges.

In my search for relevant texts between complex systems and composition, Ann Berthoff is perhaps the earliest scholar to resort directly to the chaos metaphor for understanding writing. In 1979, Berthoff’s paper presented at the Annual Meeting of the Canadian Council of Teachers of English, portrays the composing process as a continuum of making meaning out of a chaos of images, half truths, remembrances, and syntactic fragments. In her initial paper, she presents the navigation through chaos as a meaning making process. “Students can learn to write by learning the uses of chaos, which is to say, re-discovering the power of language to generate the sources of meaning” (*Learning* 7). She envisions pedagogical writing practices imbricated with chaos. By arguing that when educators teach pre-writing as a phase of the composing process, they are teaching not how to get a thesis statement but the generation and uses of chaos, and when they

teach revision as a phase of the composing process, they teach students how to re-seeing their ways out of chaos (*Learning* 6). Later in her book *Forming/Thinking/Writing*, Berthoff associates the notion of chaos with the process of invention in writing. She explains that the purpose of chaos in writing is, “not to tolerate chaos for its own sake but to learn to put up with it while you discover ways of emerging. That can be less difficult than generating chaos in the first place because, for one thing, the mind doesn’t like chaos; ordering is its natural activity. A method of composing should help you take advantage of that fact” (*Forming* 78).

In 1991, Doug Hesse presented a paper at the Annual Meeting of the National Council of Teachers, arguing that chaos provides a powerful lens for reexamining a number of issues in composition studies ranging in scale from achieving a generative model for text production to articulating the very nature of the discipline. Citing many tenets of chaotic systems such as nonlinearity, sensitivity to initial conditions, and recursive symmetry, Hesse differentiates good writers from basic writers in their ability to navigate and to adapt to complexity effectively. “They have multiple experiences and tremendous stores of discourse, with endless combinatorial possibilities. The paradox that writing teachers face, though, is how to inculcate productive complexity when oppositional student, institutional, or social needs for control demand short-term competence” (Hesse 5). Hesse concludes with the idea that metaphors can open new ways of thinking, but more research must be done before scholars can make any substantial claims or theories.

While all of these articles discuss a more holistic approach to understanding writing, and some even include ideas of chaos and nonlinearity, only McAndrew has

given even a cursory treatment of connections between complexity theory and composition. McAndrew's article "Chaos, Complexity, and Fuzziness: Science Looks at Teaching English" briefly discusses some of the major contributions of complexity theorists such as Holland, Kauffman, Langton, and Waldrop and then presents personal anecdotes through which his perspective of classroom experiences changed after considering the characteristics of complex systems. He describes how much more students can achieve through workshops, which capitalize self-organization, flexibility, diversity, feedback, and "balancing freedom with monitoring, balancing openness with reflection" (McAndrew 41). McAndrew's article informed my decision to observe a process-oriented computer classroom that engaged in regular workshops so I could observe whether chaos and complexity would emerge among student interactions.

Of the few composition scholars who have examined complex systems in writing, they generally turned to the conceptual metaphor of chaos, as opposed to complexity, for models that might generate understanding of how writers write. Apparently, these texts have made only small perturbations in the field and dissipated, most likely because they have connected to small isolated audiences, or as in the case of Cooper's article, received negative feedback.

Nevertheless, I am encouraged by the recent article by Bonnie Lenore Kyburz titled "Meaning Finds a Way: Chaos (Theory) and Composition," because she argues for many of the same points that I suggest throughout this thesis and her article was published in *College English*. Kyburz discusses chaos in terms of challenging classical and contemporary epistemological orientations, which she divides into epistemologies of order and epistemologies of chaos. She argues that, "student writing organizes with input

(like the heat to the fluids in Prigogine's experiments), as students engage in chaotic writing processes, as they exist as "variables" within the epistemic complex and as meanings emerge from within a wider cultural matrix. In this chaotic cultural matrix we see the possibility of multiple cultural and ideological influences" (509-510). She exudes optimism and enthusiasm for the potential insights and understandings that have previously remained hidden. "Reconceptualizing system dynamics via chaos theory opens our sense of possibility and allows us to conceptualize meanings in ways previously restricted by the privileging of certain kinds of order and linear thought. Theoretically, chaos opens possibilities for intervention and change (that is, Freirian "freedom") that previously seemed remote" (521). At the same time, believers in complexity share the conviction that the systems they investigate are not limited to natural phenomena but also pervade cultural, economic, political, and social systems such as the hegemonic forces that dominate the current educational system.

Dealing with the Digital Divide

In the broadest sense, the digital divide is the gap between those people and communities who have access to information and communication technologies and those who do not. As computer prices continued to fall during the mid-1990s, Internet access became the main point of contention. Educators, administrators, and researchers argued over the importance of teacher technology training, balancing funding for technology, increasing teachers' technological competence, and effective pedagogical uses of technology. The literature describing the digital divide reiterates derivatives of narratives comparing students with unlimited home access and individualized technical support with

students who must travel to a public site for a limited time and possibly slower connection speeds than affluent students. Unequal quality and quantity issues emerge from economic, geographic, and physical barriers that segregate access, speed, and content of information for different groups of people.

Information and communication technology (ICT) is now an integral part of the workplace and home for many Americans. Many researchers, educators, politicians, critics, and activists have used various studies and sources to debate the divisions between the various demographic groups of people who have access to information technologies and those who do not. During a period of unprecedented economic and technological growth, many groups began to contrast the economic success of those who had access to ICT and the economic stagnation of those who did not have access. Charles Moran simplifies the debate over the digital divide when he writes, “The issue of access is easily and quickly framed: in America wealth is unequally distributed; money buys technology; therefore technology is inequitably distributed. If we are to redistribute technology, we need to redistribute wealth. End of argument” (207). The complexity of the debate intensified when it became a political, educational, and social issue because multiple sources constructed a commonsense cultural narrative drawing the correlation between those with better access to ICT as being better prepared to succeed and prosper in an increasingly technological world (Selfe 130). Meanwhile, activists argue that those without access will fall farther behind and ultimately be excluded from participating in social, educational, political, and economic systems.

Teachers know that merely placing computers with Internet connections within the schools is not by itself enough to teach students digital literacy. Karin Wiburg points

to the need to broaden the definition of access and equity in order to understand the connections between leadership, teaching, and technology. A wide gap still exists between those who have the skills and competencies to evaluate the appropriateness of online information effectively and those who do not. As I conducted this case study, the connections between the digital divide and sensitive dependence on initial conditions began to reify when considering the economic, social, and political challenges different students face resulting from many uncontrollable elements in their lives such as when, where, how, and with whom they received their education.

Susan Lytle, Victoria Purcell-Gates, and Marcia Farr all emphasize the importance of a literacy support network to gain critical literacy skills as well as encouragement to practice and employ those skills. Purcell-Gates succinctly describes literacy acquisition in terms of material experience when she writes, “we are able to learn only what we can experience. Language learning in particular, requires both the existence of language in the environment and the opportunity to interact with language users so that one can work it out” (404). Similarly, despite a lack of formal schooling for many individuals, Farr claims that motivation is not a quantity that a person has but that it emerges from the setting out of a mixture of the participants, function, and text. If Farr is correct, an individual’s motivation to acquire technological literacy is sensitively dependent on their physical ability to access ICTs.

The Materiality of Writing

Writing occurs within a complex dynamic interaction of competing elements, involving not only social but also environmental structures, that both powerfully

constrain and also enable what writers are able to think, feel, and write. According to Syverson, “[t]here is an obvious difference between a room set up with all seats in rows facing the teacher and a room set up in a circular arrangement, which alters the learning environment in surprisingly significant ways” (9). We cannot experience life outside of our bodies, although virtual reality is beginning to test the boundaries of space and time as we experience them. For example, biometeorologists and bioclimatologists believe shifts in temperature, humidity, cloud cover, wind speed, and barometric pressure have direct, precise effects on health and behavior, and they believe our bodies are hardwired to pick up cues from the weather.

In *Writing Technology: Studies on the Materiality of Literacy*, Christina Haas presents her research on the interactions between computer users the embodiment of writing technology through numerous empirical and quasi-experimental studies and theories over the past decade. Haas frames her theoretical foundation and basic impetus for research through her interest in considering the materiality of literacy as a central puzzle which she calls, “The Technology Question.” What does it mean for language to become material? That is, what is the effect of writing and other material literacy technologies on human thinking and human culture?

In setting such a research agenda, Haas details a series of her own observational and quasi-experimental studies aimed at clarifying the factors affecting online reading results. Results of these studies on writers’ online reading problems, the effects of word processing on planning, and writers’ perception or “sense” of their digital texts have important implications on how we view the effects of computer technology on the writing process. Haas believes that by understanding how material technologies both constrain

and enable thoughts and how cultures produce, adapt, and are affected by material technologies, society must move beyond the omnipotence and transparency myths that pervade current discourse about computer technologies. While Haas primarily focuses on the individual interaction of the user and the computer interface, recent material concerns revolve around questions of access quality, quantity, and pedagogical practices. Haas' work on the materiality of writing increased my awareness of some of the material challenges writers face when writing with computers and influenced how I observed student interactions with the computers and what questions I asked during the interviews related to their physical experiences.

Ergonomics is characterized by the application of tools and principles from physical biology, synergetics (self-organization), and nonlinear dynamics. In the language of dynamics, movement systems are thought of as self-organizing systems, whereby patterns emerge from the interaction of the many variables inherent in the system. According to Kelso, the theoretical and analytical tools and principles of synergetics and nonlinear dynamics become relevant to the study of perceptual-motor systems and perceptual-motor interactions.

A key element of the dynamical systems approach is the identification of patterns (e.g. perceptual-motor patterns or interactions) relevant to the system under study. The primary strategy for identifying these patterns is to find transitions, situations in which one observes qualitative changes in the system's behavior. The transition demarcates one pattern from another, and the qualitative change allows one not only to distinguish between the patterns, but also to identify the relevant dimension of the pattern. The change surrounding the transition helps to identify the relevant variables that characterize

the pattern itself. Kelos's treatment of ergonomic transitions for studying dynamic systems informed my decision concerning how I observed classroom interactions and how I analyzed writing sessions using video recordings and screen capturing software. A second important element of the study was recognizing the stability and loss of stability of the patterns. The stability of a given pattern distinguishes patterns from each other and characterizes the state in which the system resides. Moreover, the loss of stability is probably a mechanism that effects a change in the writing process pattern.

Writers provide much of the physical structures in their own environment: annotations in books, notes on scraps of paper, list of sources, millions of websites at their fingertips of an online computer, pens, pencils, paper clips, pictures of family and friends, music playing, or even the art decorating the room in which they write. Writers are also subject to material and economic conditions that are largely outside of their control before they reach college. The writers in this case study did not suffer from many of the composing problems that earlier computer composing case studies have discussed as shown in work done by Haas, Matsuhashi, and Bridwell-Bowles et al. The most likely reason for this difference is because the writers in my case study have been using computers, word-processing programs, and the Internet for over 10 years. I observed students who consistently use the Internet for at least 5 hours a week, whereas the majority of these previous comparative studies were conducted when few people had substantial experience with computers or worked with computers regularly.

Closing Thoughts

To summarize, we know that complexity arises at the onset of chaos—the border between order and disorder. Natural systems that evolve with and learn from interaction with their immediate environment exhibit both structural order and dynamical chaos. Order is the foundation of communication between elements at any level of organization, whether that refers to a population of neurons, bees, or humans. A completely ordered universe, however, would be dead. Chaos is necessary for life. Behavioral diversity, to take an example, is fundamental to an organism's survival. Chaos, as we now understand it, is the dynamical mechanism, by which nature develops constrained and useful randomness. Emergence and self-organization generate diversity and the ability to anticipate the uncertain future.

Natural language itself shows a balance between order and randomness. On the one hand, there is a need for static structures, such as a vocabulary and a grammar, so that two people can communicate. Without a prior agreement on these, there is no basis for understanding because every utterance would be unintelligible to the listener. On the other hand, there would be no need to communicate if spoken utterances were completely predictable by the listener. In this case, the language would be a rigidly fixed structure with all possible sentences uniquely identified and identifiable. However, humans use language to communicate new information—facts, ideas, emotions, and other states of mind. Natural language as a changeable and dynamic system must be a balance of new information unpredictable by the listener and of order so that communication is understandable. As fractals beautifully illustrate mathematical equations, writing is an artistic expression of natural language.

Endnote:

1. In his study of cellular automata, Steven Wolfram classified cellular automata into four typical patterns of behavior: class 1—fixed-point and rigid structures that do not change; class 2—periodic oscillating patterns that change periodically; class 3—chaotic activity that exhibits no stability; and class 4—complex patterns that are neither too structured nor too disordered, which emerge, develop, divide, and recombine in endlessly complex ways (Wolfram 423).

Chapter Three

Methodology: Navigating the Complexity

Everything is simpler than you think and at the same time more complex than you
imagine.

Johann Wolfgang von Goethe

Overview

Every time an ethnographer approaches a qualitative study, the environment and the subjects are going to be different. Similarly, case study researchers can never exactly repeat their studies to test for reliability, unlike in many classical scientific experiments, because the specific combination of circumstances. The environment is never the same. Since most natural settings exhibit both linear and nonlinear behaviors that sensitively depend on many variables, every time an observer approaches a setting, the variables have changed in significant ways that prevent identical replication of the research. Most educators can readily identify with nonlinear behavior in their own classroom experiences. Instructors may use the same lesson plans and pedagogical practices every year and have dramatically different results because no classroom setting is the same from year to year, and every group of students brings their own idiosyncratic strengths, weaknesses, and experiences. Case studies are effective at investigating the contextual material and particular behaviors of specific events, people, or phenomena bounded by time or place (Creswell 40). This thesis is an exploratory case study; therefore, its basic function is to help identify questions and select types of measurement before a more intensive investigation.

Anthropologists and other social scientists recognized that what people say and what they do can vary significantly, making reliance on a single methodology insufficient for many qualitative studies. One of the inherent difficulties in considering complex systems is the notion that small iterations can have disproportionate net effects. I decided to conduct a case study because I wanted to investigate many different groups of variables to see which aspects of the writing process seemed most salient for further research. Of course, in order to remain within the bounds of a book, I will have to be reductive because I cannot observe and analyze everything, ask all of the questions, or account for every possible influential factor that exists in the writing process. One of the inherent difficulties when examining nonlinear complex systems is that because small changes can have large global effects, these small iterations will not predictably produce large effects, and often small changes diffuse and dissipate through feedback loops and disappear without a trace. I will integrate qualitative and quantitative aspects of the student writing processes because a single approach will not adequately reveal the complexity of the writing process.

Since Janet Emig investigated *The Composing Processes of Twelfth-Graders* and Jack Selzer described *The Composing Processes of an Engineer*, many other researchers have studied aspects of writers' composing habits from many different experiences and skill levels. Similarly, I investigated the writing processes of future scientists, veterinarians, biologists, doctors, nurses, and engineers as they developed their personal writing styles and processes in an upper-division composition course geared for the sciences. In an attempt to embody the interdisciplinary nature of my exploration, I thought that a composition course for college students in scientific majors would be an

ideal case of a multidisciplinary scenario. Most students registered the course I selected for my case study either because of their academic major's graduation requirements or to fulfill the new core curriculum requirement for a second communication course. In other words, most students probably did not register for this course because they were excited about learning more about writing techniques. Combined with the fact that some students were preparing to graduate, applying to graduate schools, working, applying for jobs, preparing for weddings, and other major life changes, plenty of external forces influenced these students' lives besides writing.

This thesis is an attempt to provide a descriptive understanding of three college students' writing processes in their natural setting. My primary focus is concerned with understanding the writing process as these students experienced it and not with evaluating the efficacy of their process. In order to suggest changes or evaluate a students' writing processes, first, it is necessary to understand the dynamics of these processes as they naturally exist. This is not to say that I do not suggest how their processes might be different or to point out the inherent inequities in current interrelated systems.

Related to the emphasis on natural setting is the view that activities must be understood within the larger context in which they occur. Historically within anthropology, the notion of holism focused attention on the fact that societies were more than the sum of their parts (although these parts were specified). Particular aspects of a society can only be understood in relation to the other aspects of society. Today, holism holds that studying an activity in isolation, without reference to the other activities with which it is connected in time and space, provides only a limited and potentially misleading understanding of that activity. So, for example, it would be of dubious value

to research online search strategies without understanding how these strategies fit into the larger set of activities of which search is but one component (e.g., in the context of online trading, shopping, or report writing).

My primary challenge in this study was to develop a methodology that would help me capture the elements of chaos and complexity that might be present in college students' writing processes. After surveying multiple possible methodologies, I decided to use multiple means of data collection and analysis to capture an in-depth understanding of the dynamic interactions between these writers' attitudes, economic constraints, social relationships, previous writing experience, familiarity and comfort using technology, time pressures, and additional interests or activities. I wanted to gain a deeper understanding about these students by using classroom observations, personal interviews, surveys, screen-capturing software, audio and video recordings, and textual analysis of written assignments and online postings. Using more than one method to analyze each student's writing process allows for triangulation that can synthesize and capitalize on the strengths while making up for some of weaknesses inherent in each method.

Epistemological Assumptions

The art of inquiry lies in asking answerable questions. As Gödel, Heisenberg, Turing, and others have argued, there are limits to what we can come to know and understand through empirical observations. However, there is value in investigating how people experience their writing processes so we, as composition educators, can develop

theories, models, and pedagogies that help more students to understand, master, and enjoy writing.

I began designing my research without an initial hypothesis. Of course, I had initial questions and assumptions that framed my design process. One key assumption is that writing is a process and the focus in examining writing should not be placed exclusively on the final product; although it does matter, writing educators should be interested in the journey and not only the destination. I spent one year as a writing consultant at the university writing center and Steven North's idea of a writing center influenced how I observed and interpreted peer workshop interactions. This process-oriented pedagogical philosophy is beneficial because the focus is to produce better writers, not necessarily better writing.

As I designed my methodology, I wanted to preserve and observe the ecological validity of the natural writing setting. I decided against using protocol analysis because I wanted to capture the natural composition environment as closely as possible with minimal interference to the process itself. In the introduction to her study, Emig wrote that students found, "composing aloud, the chief means the study employed for externalizing, an understandably difficult, artificial, and at times distracting procedure" (5). Still she claims that composing aloud is "one of the most important contributions" of her study (4). Selzer buttresses Emig's claim when he explained his rationale for not using protocol analysis because, "composing aloud can be extremely unnatural, artificial and obtrusive" (179). After reading the strong arguments surrounding protocol analysis, I decided against using this method because I was uncertain how these factors would change the natural environment that I was trying to observe.

By avoiding talk aloud protocols, I could not examine some aspects of the writing process, the immediate cognitive decisions in organization, word choice, style, etc. While immediately following the writing session, the interviews were still self-reflexive. Therefore, the unreliable nature of human memory can only reveal the writer's impressions, feelings, and fragmented and filtered recollections. I could have incorporated more qualitative methods such as relational content analysis, referential statistics, or grounded theory, but my unfamiliarity with these methods and analyses proved unrealistic considering my time and resource constraints. These other methodologies may be significantly useful for further research into this subject. In this study, I attempted to synthesize some of the methods from both of these studies in observing the natural composing processes of juniors and seniors at CSU.

Research Context

Situated outside the base of the Rocky Mountains, Fort Collins experiences a wide flux in temperature and weather patterns year-round. Simultaneous heavy snows in the mountains, severe storms on the plains, and sunshine in Denver are not unusual conditions in Colorado. And it can all change in a matter of minutes. The calendar does not give any indication about what the weather will look like outside during springtime near the Rockies. Looking out the window right now as I write this, dark storm clouds are building over the mountains. The jet stream winds circle the world like great rivers of air and as the winds flow across the Continental Divide, the Rocky Mountains create turbulence in the jet stream, which causes the weather to be very unpredictable on the easterly side (Nelson 8). It may rain this afternoon; it may hail or the clouds might pass

over without dropping a single drop of rain until they reach the eastern plains. The best that the National Weather Service can do right now is to forecast a 40 percent chance of precipitation and to issue a severe thunderstorm watch because there is a high probability of severe thunderstorms occurring in or around the local area. I have lived in Colorado most of my life and the Colorado climate epitomizes unpredictable weather. I have experienced 65-degree days when the temperature dropped in a few hours and then rained, snowed, and later the sun came out and melted the snow—all in the same day. That combination of weather patterns was definitely not in the forecast. Considering that a meteorologist, Edward Lorenz, was officially one of the first to recognize some of the characteristics of chaos, I find it useful to consider the turbulence of Colorado weather an appropriate setting of this case study and a way to observe how unexpected weather patterns might influence how students write and interact in a writing classroom.

Fort Collins is a small city with a population of approximately 120,000 predominately-white citizens. Table 3.1 compares the estimated race and ethnic composition of Fort Collins to the national average according to the U.S. Census Bureau 2000 Census.

Table 3.1 Population Race Comparisons Between Fort Collins and U.S. Average.

Race*	Fort Collins Percentage	National Percentage
White	89.6	81.05
Black/ African American	1.0	12.69
Asian	2.5	3.76
American Indian or Alaska Native	0.6	0.95
Native Hawaiian and other Pacific Islander	0.1	0.16
Two or more races	2.5	1.38
Other race	3.6	3.6
Hispanic or Latino	8.8	12.37

Source: U.S Census Bureau 2000

* Race and Hispanic origin are considered two separate concepts and therefore Hispanics may be of any race or races.

According to the Fort Collins home page (<http://www.ftcollins.com/demographics.htm>), Fort Collins averages 300 days of sunshine per year at an altitude of 4,984 feet. The average median family income is \$54,000 per year, and while CSU is the largest employer in the city of Fort Collins, other major employers include the Poudre School District, Hewlett Packard, Poudre Valley Health Systems, Eastman Kodak, Larimer County, Agilent Technologies, and the City of Fort Collins. As far as recreational attractions, students are near to mountains, ski resorts, campgrounds, bicycle routes, hiking trails, concerts, movies, sporting events, and Fort Collins has the most micro-breweries per capita in Colorado.

This case study research took place at CSU during the spring of 2004. CSU is a land-grant institution with a Carnegie classification as a level-one research university. CSU is a medium-sized land grant university with a student to faculty ratio of 17:1. Colorado residents constitute 78 percent of the 24,700-student population. The cost for undergraduate tuition and fees for 2003-2004 is \$3,744 for Colorado residents and \$14,216 for nonresidents. According to the CSU web site, the estimated annual cost for a full-time Colorado resident student is \$12,865.

One of the primary considerations for this case study was to explore how students utilized the technological resources available to them to research and develop their writing. This university has invested in developing a campus-wide communications network, incorporating many computer-networked classrooms into the curriculum. For example, all core buildings on campus have wireless access points and the university provides every student with a free university e-mail address and space for a personal

website on a university server. Students can conduct the majority of administrative functions, from class registration and financial services to changing addresses and searching for job listings, through the university's online system *RamWeb*. CSU's fiber optic network supports communication across the university, allows access to the Internet, and enables classrooms to interact online outside of classroom-scheduled hours through online discussion forums through *WebCT*, *Syllabase*, and *Writing Studio*. On campus, there are more than 50 student computer labs with more than 3,500 computers that offer scanning, multimedia, e-mail, Internet access, many popular software titles, and high quality print capability. The Morgan Library provides over 300 public computer terminals as well as laptop computers for checkout and use in the library.

The specific course that I selected to use for this case study was COCC 301B – Writing in the Scientific Disciplines. COCC301B is a computer-networked upper-division composition course designed to teach students from scientific majors how to incorporate various rhetorical devices and techniques to improve their writing for general audiences. Students taking the course learn about and practice writing a wide range of essays, including those that explain, interpret, react to, or reflect on specific science-related issues. For example, some of the major emphases in the class were getting students to recognize the interests and needs of their audience, defining the audience, using active voice while avoiding passive voice, citing sources in a non-academic fashion, and employing elements of visual rhetoric. As shown in the course syllabus (see Appendix A) the first six weeks of the course focus on analyses and responses to readings, while the rest of the semester is devoted to student production of two portfolio projects including several articles or essays (see Appendix B).

This course met at 8:00 a.m. until 9:15 a.m. on Tuesdays and Thursdays in a computer-networked classroom equipped with 24 Dell Optiplex 260 desktop computers, running with Windows XP operating systems, each equipped with a 17" flat panel display monitor and a 2.66 GHz Intel Pentium 4 processor. This course utilized the *Writing Studio* program (<http://writing.colostate.edu/studio>) at Writing@CSU (<http://writing.colostate.edu>). The *Writing Studio* provides a space to help students organize their class information, assignments, and projects while providing a series of links to information such as the class calendar, syllabus, assignments, forums, and e-mail lists. While the instructor may use all or only some of these features, this course's instructor used the class calendar, syllabus, assignments, forums, and e-mail features regularly. The classroom was arranged as shown in Appendix C, with computer terminals for each student around the perimeter of the classroom, a cluster of five tables in the center of the room and a white board at the west end of the room. There were no windows, the lighting was slightly dim, and a small sign indicating no food or beverages were allowed in the room. There were no decorations on the white walls besides two posters impressionistic flower paintings on opposite sides.

Participants

Instructor

The professor, "Madison," had many years of composition experience in both traditional and computer-networked classrooms at the university level and she had not taught composition in a traditional classroom since 1988. Madison's vision for this course was to get students to understand that, as writers, they make choices about their

writing based on the rhetorical context or the writing situation within which they are working. She emphasized that students need to practice identifying not only the topic they need to or want to write about, but also the readers who will have some exigence for reading the text. Madison assumes that students will need to continue to adapt their writing in various situations after college, so the most effective approach is to emphasize how understanding rhetorical context gives them the best chance of communicating effectively no matter what situations they find themselves in.

Socio-cognitive theories and models of andragogy informed Madison's teaching philosophy and rhetorical approach. She described how people read texts in a variety of contexts and begin to create internal mental models that meet the reader's needs communicating a message and shaping interpretation. She argued that, "unless students work through the process of analyzing rhetorical context and writing for that context several times with guidance, they are less likely to learn various strategies for adapting their knowledge in new contexts."

Madison incorporated a cognitive apprenticeship model along with notion of andragogy (theories of how adults learn) in her classroom instruction. Models of andragogy assume that adults need to know why they need to learn something, adults need to learn experientially, adults approach learning as problem-solving, and adults learn best when the topic is of immediate value. In practical terms, andragogy means that instruction for adults needs to focus more on the process and less on the content being taught. Instructors adopt roles as a facilitator or a writing resource rather than a lecturer or an evaluator. Madison described her use of andragogy by saying:

Although I don't set up explicit contracts for different levels of work, I do try to make students aware that they set their own bar for performance in terms of the number of pages they complete, how often they participate in activities, including my review of the drafts, and so on. As student interest changes, I find myself making those points more or less explicit. My experience this term suggests that we're moving into a phase where students need more explicit contractual language to see what I'm doing, perhaps because students are less motivated when they're taking the class now.

Madison used daily writing assignments and questions to set a routine that students can expect and get students writing on the computers intended to help them brainstorm and formulate some thoughts about their writing. Madison asked every student to turn in a "medium draft" for the first portfolio, not for a grade but for her to write comments so students would have a better understanding of her expectations and grading criteria. In Madison's responses to student drafts or final products, she incorporated direct comments on the draft as well as attached a typed page of commentary on the student's strengths and areas for improvement. In terms of commenting on drafts, Madison explained that she comments extensively on the early drafts to give students an idea of her level of expectations, but she added that students often raise their own standards in terms of demonstrating their abilities.

In terms of evaluation, she described her grading criteria in the following way:

A C paper in 301 is competently written (meaning readers can get from the beginning to the end without major glitches in understanding the text),

but it doesn't make any special efforts to accommodate particular audience needs. A B paper does accommodate the audience, at least in terms of filling in required background knowledge, defining terms, providing clear explanations, drawing on appropriate expert sources, and setting up readable chunks of text. An A paper takes the next step to crafting the paper, especially stylistically, to draw readers in most effectively and keep their attention throughout the text. These papers often have effective visual elements as well as clear layout, and diction/sentence style that are distinctively stronger than the average B paper.

Afterward she confessed that, "Everyone seems to think I grade too hard." Overall, Madison explained that developmentally, these writers already know and have already practiced most of the specific writing strategies they will need to succeed in this class, but she is also aware that for much of their college writing, they have written primarily for an academic audience; therefore, they may not be particularly astute in writing for other audiences.

Students

Twenty-three students registered for the morning section of COCC301B and they represented a wide range of economic, social, and academic interests. The students represented 11 different scientific majors including Biochemistry, Biology, Biomedical Sciences, Environmental Engineering, Math, Microbiology, Molecular Biology, Natural Resource Recreation & Tourism, Physics, Wildlife Biology, and Zoology. The course was nearly evenly divided with 10 females and 13 males. There were no minors (under

18 years old) in the course because this upper-division course does not allow freshmen. Although almost racially homogenous, this class represented a wide range of economic backgrounds with students' parents who had annual incomes ranging from under \$20,000 to more than \$170,000. Individual students' incomes were more similar with 15 student annual incomes below \$15,000. Most of these students worked jobs outside of their academic studies. Only 4 students in the class did not work, and most students worked between 15 and 20 hours each week. When considering these students' academic motivations, 7 students reported hoping to earn a doctorate degree, 7 students planning on achieving a master's degree or first professional degree, and the remaining students were either undecided or focused on earning their baccalaureate degree. All students participated in class as usual and 21 out of 23 students completed all three surveys.

Case Study Participants

I received approval to conduct this study from the CSU Human Research Committee and their restrictions guided some of my selection criteria. After introducing my research interests to the class with a recruitment script, I distributed consent forms for the students to agree for me to observe their class throughout the semester, to which every student agreed. To maintain confidentiality, I asked the students to fill out a six-digit identification number made from a combination of their birth month, and the last two digits from a telephone number and zip code. I would use these identification numbers throughout the remainder of the study to track individual student responses while maintaining their confidentiality. To select the three case study participants, I distributed an initial survey to the entire class (see Appendix D) and asked volunteers to

participate in the survey by placing their e-mail address or telephone number on the survey to indicate their interest in participating in the study. I told the students during my recruiting visit to the class that, to compensate for completing writing sessions, surveys, and interviews, I would paid them incrementally over the course of the semester for a total of \$75, if they completed every aspect of the study. I received six initial volunteers and I randomly selected the case study participants, which included one junior male, “Dan,” and two senior female students, “Ashley” and “Emily.”

Ashley was a 21-year-old senior graduating with a degree in Zoology. She planned to return to CSU in the fall to take some additional prerequisite courses so she could enroll into a nursing program the next year. She originally came to CSU wanting to become a veterinarian because she liked animals, growing up with three cats and two dogs and currently living with one cat and one dog, and she admitted that she did not like working with people. She grew up in Colorado Springs and her mother, who was a teacher, and her father, who was a doctor. Her parents always encouraged Ashley to go to college after high school. Ashley lived a couple miles from campus in an apartment that her parents owned and she drove the car that her parents bought her for a high school graduation present. Her parents paid for all of her educational and living expenses plus extra spending money. Somewhat apologetically, she confessed, “I know that I’m spoiled, but my parents are willing to pay for everything...I’m okay with that.” She wrote at home and at school in the computer labs depending on which was more convenient, but she typically tried to do her homework at school because home was her “sanctuary” to relax from work. Ashley also maintained an internship at the CSU Veterinary Clinic for 10 to 12 hours per week and she discovered that dealing with people is not as bad as she

previously thought. Periodically throughout the week and on most weekends, she spent time with her boyfriend.

Dan was a 25-year-old junior guest student majoring in Wildlife Biology. He grew up on the western slope of Colorado in Montrose. Struggling to find a way through school academically and financially, his divorced parents were supportive and willing to make significant sacrifices to help him through school. Midway through the semester, Dan had to cut a writing session short because he found out that day that the registrar was going to put his registration on hold until he could pay his \$1400 debt to CSU. His mother sold her car and gave him the profits so that he could pay for classes. Dan juggled several jobs throughout the semester to keep working 20 to 30 hours a week or more on Fort Collins' struggling economy in order to pay for living expenses. Dan moved during the semester because his roommates suddenly absconded, leaving him with a rent that he could not afford. One of the companies Dan worked for laid him off since the company was downsizing because of decreased demand for its product and services. Dan's hopes were to graduate from CSU and go work for the Department of Wildlife, but knowing the steep competition for positions and his academic record, he remained uncertain about what he would do after college. If he was unable to find a job in his field, he speculated that he might go back to Montrose to do some landscape surveying work with his father.

Emily was a 22-year-old senior graduating that semester in Microbiology. She lived in an apartment with her fiancé two blocks from campus and that is where she did most of her homework and writing. Emily was born in Denver and she recalled how her mother always said that she liked words when she was growing up. Her mother was an elementary school teacher and her father was a lawyer. Her passion for microbiology

emerged in high school when doctors diagnosed her father with cancer. It was a very difficult time for her, but she was also excited to be in hospitals and she developed a strong curiosity for how cells worked. She wanted to know more about how to help her father get better and later how she could eventually help others to overcome cancer. Her father recovered from cancer before she graduated from high school. Her parents paid for the majority, but not all, of her educational and living expenses. She maintained an internship at the CSU Veterinary clinic 10 to 12 hours per week for spending money and beneficial work experience related to her academic interests. Throughout the semester, Emily was planning for her wedding in the summer and then she planned to move to New York in the fall to attend graduate school. Her dream was to become a pathologist and search for improved treatments for cancer cells, specifically leukemia. The parts that intrigued her most about studying cancerous cells was how the same type of cancer will affect people differently, how diseases evolve over time, and how to combat diseases more effectively.

Data Collection

In order to capture the complexity of the writing process, I used multiple sources of data collection and analyzed the students' writing and processes at various levels of scale. Classroom observations served to present local and global social interactions over the course of the semester between students and the instructor, as well as general trends for the entire class as far as providing and receiving feedback on their writing and how they interacted with the computers in the classroom to compose their texts. The interview questions captured the student's reflection on their writing, their writing environment,

and other physiological, emotional, and psychological factors influencing their writing process. Surveys attempted to capture demographic, social, economic resources and limitations students experienced in their writing courses as well as attitudes and habits about writing and technology. Written texts, online postings, and workshop comments provided the material evidence of the writing process as it emerged from prewriting, drafting, and revising as well as community reactions and interactions to course material. Screen capturing software recorded every mouse click, keystroke, pause, and edit throughout the writing sessions. The video recording captured the writers' physical posture, use of articles, sources, other texts, etc. in formulating their writing process in real time.

Observations

One of the fundamental axioms in the social sciences, and anthropology in particular, is that what people say they do and what they actually do are not always the same. A wide variety of factors can cause discrepancies between verbal reports and people's actual behavior. People may be concerned with their image and so report, consciously or not, behavior that is more socially acceptable. Along these same lines, a participant may respond to a question in a particular way in an attempt to please the researcher. Another source of disparity between behavior and verbal reports is that often people are not aware of their actual behavior because it is so habitual. According to Roy D'Andrade, such tacit knowledge is often not easily accessible through interview techniques. The limitation of human memory is another reason why interview data can differ from observation. When asking participants about past events, or recurring patterns

of behavior, our memory may be selective and skew responses in any number of directions. The complexity of social life is another reason individual accounts may miss certain relevant details. The environments in which humans interact are extremely dynamic and complex—composed of social relationships, artifacts, and physical spaces—which can make it difficult for individuals to fully envision, let alone articulate, after the fact, what is going on or what has happened.

I conducted eight classroom observations out of a total of thirty scheduled class meetings throughout the semester. I selected the class periods to observe based on the syllabus activities planned for each session, my personal availability to conduct the observation, and Madison's advice concerning the days when students were most likely to write on the computers, workshop drafts, and work in groups or have personal conferences with the instructor.

My observations became more specific as I become more familiar with the classroom dynamics, case study personalities, and the embodiment of complex adaptive systems in this writing course. While observing the classroom interactions, I kept my research questions in mind looking for physical interactions of students with the computers, other students, and the teacher. I recorded observations about spatial and temporal dynamics, student adjustments to the environment, conversation level in the classroom, topics of conversation, and observable strategies students used while writing on the computers.

I assumed the role as an observer-participant. In this role, I attempted to be as unobtrusive as possible. I did not respond to the instructor's questions, write on the discussion forums, participate in workshops by actively editing another student's work,

or turn in written assignments. When I came to observe the class, I sat in the back corner of the room, which allowed me to have a full view of all students and their body language and actions during lectures. During workshops and class work time, I recorded my observations while randomly walking around the classroom and observing students' interactions with each other, the instructor, and the computers. I tried to distribute my observation time evenly throughout the class period, remaining long enough observing students to recognize patterns, conversations, and concerns, but short enough to be able to observe all students during the class period. I recorded my notes and observations through narrative descriptions and real time manual transcriptions of classroom dialogue using a personal shorthand notation.

Surveys

I used surveys to gain understanding about the attitudes, habits, and perceptions this classroom of students had about writing and technology in a relatively quick and efficient manner without excessively detracting from class instruction. The portion of the surveys that tracked student attitudes about writing and computers was adapted from Palmquist and Young's study "The Notion of Giftedness and Student Expectations About Writing." I generated the remainder of the survey questions. I used pilot surveys on a combination of three graduate and three undergraduate students to test for clarity and comprehensibility. I made some minor changes to the wording and format in response to these pilot surveys. I administered three surveys for the entire class at the beginning, middle, and end of the semester (see Appendix D). The surveys are a combination of Likert-scale and open and closed-ended questions to address the students' interests and

opinions on writing, computers, and their self-assessed writing habits. These surveys also collected demographic, racial, economic, social, and cultural information.

I was available in the classroom when students completed surveys to answer any questions. Some students were absent multiple days and it was not possible to get survey responses from all of the students. I received all of the initial surveys, 21 of the mid-semester surveys, and 20 of the final surveys. Each survey took students approximately ten to fifteen minutes to complete and I assured their confidentiality by using the six-digit identification numbers described earlier. The confidentiality combined with identification numbers encouraged honest responses and allowed me to track individual responses during the semester.

Writing Sessions

All three case study participants completed three one-hour writing sessions at different stages in their writing processes. The first writing session captured predominantly their revision processes as they finished their first portfolio projects. The second writing session provided insight into more of their prewriting and drafting processes. The third session was a combination of prewriting, drafting, and revision depending on their stage in the process as they approached the end of the semester. Each writer wrote in a different location. Emily wrote in the study room of her apartment, which had two computers and a window. Dan preferred to write in the computer labs at CSU facing a wall to prevent distractions. Ashley wrote at home and at school depending on which place was more convenient at the time, but for each of the writing sessions she preferred to write in a CSU computer lab. After receiving their consent, I meet them at

their typical writing location and recorded their writing processes using screen capturing software, video recordings, and interviews. I encouraged the students to be as natural and comfortable as possible. I assured them that they were free to walk around, get water, or go to the bathroom. After setting up the computer software and video camera, I left room and allowed the writers to compose their texts for COCC301B in a naturalistic setting. I returned one-hour later and interviewed each writer to gain some immediate responses to their work during the session.

Screen Capturing Software

Professor Luuk Van Waes, from the University of Antwerp, is the principle researcher in the development of a keystroke and screen-capturing program named *Inputlog*. He graciously provided a demo version of the software for this case study. *Inputlog* is a logging tool that enables researchers to log the input from the mouse, keyboard, and speech of a writing session in a *Microsoft Windows* environment. After recording the writing session, *Inputlog* can generate different data files from the source logging file for statistical, text, pause and mode analyses. *Inputlog* will exactly replicate the writing session in real time or at different playback speeds. The most important feature of *Inputlog* is that it is a logging tool that enables researchers to log writing sessions in *Microsoft Word*. Other logging tools create their own word processor to log keystrokes, but *Inputlog* logs the data directly from *Microsoft Windows*. Considering that the majority of the computer terminals at CSU use *Microsoft Windows XP*, this program was quick, easy, and convenient to use for this case study.

Video

In an attempt to minimize the effect of observing students compose in their natural setting, I set up a digital video camera to record the composition process in the students' natural composition setting. I recorded the entire composition setting, decorations, resources, lighting, etc. The purpose of using the video camera was two-fold. It allowed me to leave the room and remove the pressure on the writer's of feeling someone look over their shoulder as they wrote. I think the use of the video camera was beneficial because, as Madison explained in an interview, students sometimes felt uncomfortable when people looked over their shoulder as they wrote and would not write or they would close the document window and work on something else. The video camera also allowed me to record each writer's material interaction with the computer interface and peripherals for further conceptual content analysis later that would have been otherwise impossible to record by hand. The video recorded visible signs of the writer's discomfort, when they adjusted their environment, stretched, and other physical interests in this study.

Student Interviews

After each writing session, I interviewed each writer for approximately one hour about things I had observed from classroom interactions, previous writing sessions, comments they made, responses to surveys, and about the principles and attitudes that shape their habits. The interviews informed my classroom observations and provided psychological insights into their personal perspectives on their writing processes as the study progressed. In the beginning of fieldwork, the interviews were often open-ended

and relatively unstructured. This approach gave me the flexibility of altering the line of questioning as the interviews unfolded. Throughout the process, I was learning the interesting questions to ask. (See Appendices G, H, and I for student interview questions and Appendix J for the teacher questionnaires). I had a loose interview protocol and developed general or specific questions to ask from observations in class or previous writing sessions. My questions became more focused as I observed characteristics of chaos and complexity in their writing processes.

I assume that I am filtering data and information through the lens of the theories of writing, literacy practices, chaos, complexity, and aspects of rhetoric and composition to which I have become accustomed. I made subjective decisions along the way in deciding what questions to ask to test the existence of elements of chaos or complexity in their writing. I did not directly use terminology from chaos or complexity, because students were not familiar with these concepts, so I found ways to ask questions that might provide or reject evidence for these characteristics.

I wrote responses and comments about students' physical condition and gestures to on a notepad and tape-recorded and transcribed each conversation. The interviews mainly occurred one-to-one with no other people in the same room. I encouraged students to make themselves comfortable. I offered them water, encouraged to get up, stretch, move around if they needed to or go to the bathroom at any time.

Teacher Questionnaires

At the beginning, middle, and end of the semester, I e-mailed questionnaires to the instructor to gain perspectives on how she perceived the course purpose, practices,

and student performance. I intended for these questionnaires provide a comparison of the similarities and differences between the students' and the instructor's perceptions of the course.

Written Artifacts

In accordance with the consent forms the case study participants agreed to, I collected copies of all workshop drafts, final portfolio projects, instructor grades and comments, and discussion forum postings for textual analysis. I wanted to collect the actual texts to analyze the comments and revisions of the material drafts these students used to create their portfolios. This course required that students produce multiple drafts and have them edited by other students in the class, therefore, these drafts provide evidence of the writing process as it evolved over the course of the semester.

Personal Reflections

I asked the case study participants to use a self-reporting technique through personal responses to regular weekly prompts and other personal insights into their personal writing processes, but all of the case study participants declined. I made this additional task optional including supplementary compensation for their time. They all cited time constraints for preventing them from making consistent, honest, and thoughtful responses. I appreciated their candor and decided to proceed with the study without this introspective perspective. I was still able to gain some insights into these issues from interviews, survey responses, and other written work.

Data Analysis

The analysis of the data collected throughout this study attempted to determine the degree of the influence of various attractors in the complex systems of the physical-material environment on the writing process. I used the results from the observations to present a narrative description. I traced each student's writing process from the writing sessions during the semester by primarily using textual analysis of the *Inputlog* recordings, writer's drafts, workshop comments, teacher comments, completed texts, online discussion forum postings, interview transcriptions, the finished texts from each of the three participating students. I read each text multiple times looking for common words, phrases, and ideas throughout the text. I analyzed changes within the text between drafts resulting from peer and instructor feedback. I traced the changes in sentence length, organization, total words, and other quantitative qualities of their texts. I recorded elements of ethos, logos, and pathos in their attempts to interest the reader and persuade them to understand their position. I compared drafts, workshop comments, and final versions that students turned in for the final portfolio project for the prevalence of ideas, point of view, repetition of concepts, changes in their text, and their uses of visual rhetoric.

Considering that the human mind is adept at recognizing patterns and lacking any software to analyze the video sessions, I decided that I would conduct a textual analysis manually combined with their responses to interview questions to illustrate aspects of the students' writing processes. I parsed the nine video writing sessions into actions, activities, and then coding the parsed segments into different sections of the writing process such as reading, typing, reviewing notes, and physical movements.

I used descriptive statistics to describe the survey results and *Inputlog*'s statistical analyses for each writing session to illustrate the quantitative aspects of their writing. My intention is to integrate these multiple forms of data analyses into a coherent thick description of these students' writing processes to reveal possible connections and incongruities of chaos and complexity.

Chapter Four

Results and Discussion: Writing on the Edge

Overview

Returning to my research questions and aims, the overall purpose of my research was to investigate possible connections between chaos and complexity and the writing process. My research questions are:

- How does the class setting shape activity within the classroom?
- What are student attitudes towards reading, writing, and computers?
- What material resources do students use when they approach a composition assignment?

The following results describe three very individual writing processes and styles. First, I will present the overall class findings from classroom observations and surveys according to my research questions. Second, I will describe the individual writing processes of Ashley, Dan, and Emily by following their writing chronologically through the semester portfolio projects. Then I will conclude the chapter with a general discussion of the writing process in terms of this study's findings, patterns, and questions as they relate to chaos and complexity.

How Did the Class Setting Shape Activity within the Classroom?

When I observed the entire classroom, I wanted to observe student and teacher interaction with each other and the computers in the room. While I had the concepts of chaos and complexity in my mind, my focus was to write a narrative of the events as they happened by describing the environment, conversations, and physical interactions of all

participants. Classroom observations primarily provided a means to observe interactions between students and the teacher and between students and the computers. The most significant aspects of classroom meetings on these students' writing processes were Madison's instructions and advice on writing techniques and the peer critique workshops.

The single most significant writing process that I was able to observe was the interactions students and Madison provided in the revision and feedback to drafts of their portfolio writing. I did not observe many students drafting or revising large portions of their texts in class; instead students used the majority of the time to give and receive feedback or discuss their ideas with Madison and other students. My narrative descriptions of the events, as they emerged throughout eight of thirty scheduled class meetings, portray an environment filled with independent agents acting on limited knowledge through networks of feedback loops while self-organizing and engaging in rich interactions, adapting to diverse circumstances, and negotiating through differing experiences. The following is an example description of the first fifteen minutes of a particular class period.

April 29, 2004 – Yesterday the skies were blue, the sun was shining in Fort Collins, Colorado with a comfortable high temperature of 77 degrees Fahrenheit. Birds were chirping and singing around the campus, a gentle northeasterly wind blew to cool off students as they walked, rode their bikes, and drove to and from campus. The forecast for today was for slightly cooler temperatures and partly cloudy skies. Today, CSU is engulfed in a cloud of drizzle freezing into snowflakes, blustering north winds and students rudely awakened by frozen sidewalks and winter winds

blasting fragile spring flowers recently beginning to sprout from their dormancy during the winter cold. Students slowly filter into the classroom intermittently after eight o'clock in the morning. Students come in bundled in their winter coats and with surly and half-asleep countenances. Students find their adjustable chairs, leaving the broken ones for those who showed up late. Some students exhibiting zombie-like behavior walk into the classroom and directly find their unassigned computer stations that they have claimed since the beginning of the semester. They slump down into their adjustable chairs and begin to type as one-by-one the computer screens begin to glow around the room. A quiet hush builds into broken whispers and hundreds of intermittent keystrokes increasing the noise and cacophonous orchestra of papers shuffling, mice clicking, and computers humming. Could patterns emerge from this dynamic and apparently random setting? What patterns would we see if we examined the interactions from multiple scales? At what scale would this information begin to make sense? How should we perceive the patterns? How do these patterns represent changes in space, time, or motion?

A problem with the printer requires the instructor's attention as students try to print out workshop evaluation sheets for the peer editing session scheduled for today. Madison asks a student how they are feeling and she responds bitterly about the injustice of snow this late in the spring. Others overhear the conversation and another student says, "Oh, I've known it to snow in June and July in Colorado." Some other students

notice the current thread of classroom conversation and small conversations build around the room. "I need to watch the Weather channel more often," one student admits. Another student says, "I always check WeatherBug online before I leave for the day." Another student recounts his tale of the freak storm that dropped three feet of snow in Denver weeks before meteorologists were predicting the first snowstorm of the winter and another time when it was snowing while the sun was still shining. In any group of people, weather is perhaps the most common phenomenon that can bond their stories, emotions, and experiences while giving even complete strangers something about which to talk. Colorado weather is infamous for being unpredictable and most natives are familiar of the cliché, "If you don't like the weather in Colorado, just wait fifteen minutes." That statement was almost true, or at least it felt like it.

This was a somewhat typical scene from COCC301B, except, of course, the weather fluctuated and some students unpredictably brought higher energy levels and alertness into classroom. Some of the emergent behavior patterns that emerged over the course of the semester resulted from several initial institutional conditions, which framed the course. A typical day began with students to file slowly into the room after it was unlocked, and the majority of students woke up and became more energetic as the class progressed. Discussions among students, conversations with Madison, and responses to surveys repetitively complained about the course beginning too early in the morning making it difficult to attend classes at times. When students were present, students reported that the early start time inhibited their ability to participate and learn effectively

because they were usually tired or not alert until the end of class. For example, while referring to the *Microsoft Word* assistant, one student said, “The little dog is cute. That’s how I know I’m tired, because I’m talking about a computer dog. Oh look, it’s all happy because I’m about to print.” Students also reported that sleeping in and having an early class were the most significant reasons for any absences throughout the semester.

Although I did not compare several classes to compare effects from the time of day of the class meetings, additional research may be able to determine if the time of day of the course may have significant effects on students’ interactions and its impact on student writing, feedback and workshop effectiveness.

The room arrangement provided a computer for each student and the majority of the students became territorial over their unassigned, but territorially claimed computer stations, except for students who typically arrived late, who chose from the chairs and computers left unclaimed. During my observations, students rarely used the tables in the center of the room, except during workshops to edit peer drafts on hard copy. Although the chairs, monitors, and peripherals were adjustable, few students made observable adjustments to these items to fit their personal dimensions and comfort. During class lectures, most students remained seated around the perimeter of the room. Unless Madison was using the overhead projector and students could not comfortably see the screen, only then would they move from their seats to another position in the room or to the tables in the center. A handful of students actively wrote notes by hand during lectures, but no students used the computers to take notes.

Very rarely did I observe a classroom meeting when students did not come into class and begin working on or using the computers. Computers provided a tool for

students to begin working immediately upon entering the classroom. Computers enabled many students to multi-task before, during, and after class. Students navigated multiple windows screens switching between the class calendar and forums on the *Writing Studio*, to *Microsoft Word*, to an online dictionary or informational website, e-mail and other tasks. Students used any spare moments to check their e-mail, play games like Solitaire, search for airline flights, or shop for items to buy or sell online, but the majority of the time students researched, wrote, edited, and revised.

Self-organizing principles demonstrated their presence within this classroom in student interactions as well as students' individual writing processes. Madison allowed students to self-organize into groups for workshops and several class discussions for the online forums. Although Madison encouraged students to get opinions from several different students, several students preferred to receive feedback from the same self-selected groups of students. In addition, students continually adapted their personal writing styles by incorporating various methods, vocabularies, metaphors, styles, arrangements, and many other writing techniques that they experienced.

During workshop days, students engaged in observable dynamic interactions embodying feedback loops and the adaptive nature of student writing processes. Previous class lectures and discussions focused on avoiding passive voice, using appropriate diction for specific audiences, and incorporating visual rhetoric to attract a reader's attention. During workshop class periods for the second portfolio, I observed many one-on-one sessions where students were providing feedback incorporating the elements that previously learned and practiced in the first portfolio.

As I observed each classroom meeting, I experienced the same phenomenon that Mitchell Feigenbaum experienced during his walks. The events, conversations and interactions in the classroom were so rich and complex, I could really only make meaning out of the interactions I was directly focusing on. If I switched to observe or listen to another conversation, I lost the other interactions—they became background noise and seemingly random because I was not analyzing them at the level at which meaning could emerge.

While I attempted to maintain a primarily observatory role during the class, I recognize that my presence influenced the environment. Multiple times throughout the semester, students talked directly to me, asked me questions about my research, or even talked or wrote about me. I do not know how my presence may have changed how students provided feedback during workshops, but several students said things such as, “This guy is writing down everything we are saying,” “you didn’t hear me say that,” or “be sure to put in there how...” I was surprised to find that Dan alluded to me in a text he turned in with his first portfolio. Dan wrote a three-page informative advice column for future COCC301B students to read about their expectations and understandings for the course purposes. After illustrating the scope and the difficulties of “writing about science writing,” he wrote:

Though it is difficult to come up with several pages’ worth of constructive criticism on the work of people who are paid to write, it is the subtle details you begin to notice that will make you a better writer. And hey, it could be worse. You could be that poor guy who’s doing his master’s

thesis on the writing processes...writing about people who write about science writers. That can make you dizzy.

I also noticed my impact through some of the revisions and comments that Dan, Emily, and Ashley made during the interviews. Numerous times throughout the interviews, I asked these students questions about their writing and they told me that they had not considered some aspects of their writing that they probably should have considered. Later, I saw evidence or changes in their final texts related to our conversations.

Student Attitudes towards Reading, Writing, and Computers

Given the small sample size for these surveys from one class of 23 students, I will present all survey findings in terms of numbers of students to avoid presenting potentially deceptive percentages. Out of 23 students, 21 students completed all three surveys and one student's responses were not included in the results because many of his answers were obviously fallacious. Therefore, the class survey results represent the responses from one class of 20 students. I tracked student survey responses over the course of the semester to see how their attitudes towards reading, writing, and computers changed throughout the semester.

The majority of students had positive impressions about technology, their ability to use computers, and the idea that computers could help them to get more work done efficiently. Fifteen students agreed that computers are necessary in educational or work settings. None of the students indicated that they were intimidated by computers and 12 students agreed that they would like to learn more about using technology, but only 4 students agreed with the statement that learning about computers was exciting. All of the

students agreed with the statement that they were confident that they could learn computer skills. When asked if they felt that computers made homework easier, 17 students agreed. The majority (14 students) agreed that they thought the Internet was good at connecting people and enhancing communication, but only 5 students reported using e-mail to communicate with classmates or teachers outside of class voluntarily.

Most students reported that they were too busy with classes and working to use the Internet for entertainment purposes. The questions asking about their online activities asked for typical online habits and the amount of time spent during a given week. Out of 20 students, all replied that they used the Internet to check their e-mail and conduct research on a regular basis, which contributed to the majority of the time they spent online (over 75 percent for 12 students). The next most popular online activities were reading news and current events as well as checking the weather. The average amount of time that students, who reported reading the news or current events online, reported reading the news online was three hours a week. Instant messaging and online chat discussions were regularly used by 6 students while 5 students reported using the Internet to listen to music, shop, or manage their banking accounts. Only 3 students reported playing computer games online. One student reported regularly keeping a blog and one student reported participating in a MUD for 10 hours a week. Incidentally, reported activities are more valuable than student time estimates for each activity because reported time estimations were contradictory. Students typically underestimated the total number of hours they spent online each week compared to the sum of the amount of time they spent for each activity each week.

General trends in student attitudes towards writing and computers were difficult to find because the changes were so individualized and diverse. As you can tell from selected responses in Table 4.1, the majority of these students believed that they could improve their writing and they felt confident about their writing abilities. On the other hand, many students verbalized their complaints, in class and online discussion forums, about the prospect of writing science for general audiences because they felt that science is too “dumbed down” or oversimplified to the point of gross distortion by the mainstream media.

Table 4.1 Attitudes about Writing: Numbers of Student Responses from Survey 3

Statement	Agree	Disagree	Neutral
I use a computer or word processor to prepare reports or papers	20	0	0
I use e-mail to communicate with an instructor about coursework	15	0	5
I search the Internet for information related to a course	18	0	2
I use a computer to retrieve materials from a database or online journals	18	0	2
Use a computer to produce visual displays of information (charts, graphs, spreadsheets, etc.)	13	1	6
I switch between different windows, applications, and programs while I write	15	3	2
I listen to music while writing	12	4	4
Practice is the most important part of being a good writer	16	1	3
I am able to express myself clearly in my writing	14	2	4
Good teachers can help me become a better writer	15	0	5
I am not good at writing	4	12	4
Other students who have read my writing think I am a good writer	12	1	7

Table 4.2 Attitudes about Computers: Numbers of Student Responses from Survey 3

Statement	Agree	Disagree	Neutral
I am confident that I can learn computer skills	18	0	2
Any patient and motivated person can learn to use a computer	15	1	4

Learning to operate computers is like learning any new skill— the more you practice, the better you become	17	0	3
I feel apprehensive about working with computers	3	14	3
I have difficulty understanding the technical aspects of computers	5	13	2
It scares me to think that I could cause the computer to destroy a large amount of information by hitting the wrong key	3	13	4
You have to be a genius to understand all the special commands used by most computer programs	3	14	3
I avoid computers because they are unfamiliar and intimidating	1	19	0
Computers are necessary tools in both educational and work settings	17	0	3

The survey results suggest that about half of the students in this class prefer to write in solitude. Students reported that they never write while talking to someone else either face-to-face, by telephone, e-mail, or instant messenger.

What Material Resources do Students Use When They Approach a Composition Assignment?

Students had the same basic resources in the classroom, identical computers with access to the Internet, *Writing Studio*, online articles, printers, and they had the same institutional resources including the campus library, computer networks, and the CSU Writing Center. How students used these resources varied widely, especially when students worked together in groups. During peer workshop days, some students read texts on the computer screens, while others preferred to print them out and edit them by hand. Some preferred to type their responses to the critique questions in *Microsoft Word* and then cut and paste their responses into the *Writing Studio*, while other printed out the

critique sheets and wrote their responses by hand. One student used remote desktop to access his personal home computer and information at home. None of the case study participants had ever used the CSU Writing Center, a free resource for all students, but all of them were aware of the Writing Center and the services they offered. The largest reason students cited for not using the writing center was a lack of time.

Every student had access to computers and the Internet either at home (16 students) or at school (20 students). Only 2 students indicated that their home computer was less than one year old. When asked where they accessed the Internet most often, 16 students used home access and 7 students used school provided computers most often. None of the students who used the computers at school the most often had home access. Over 19 students experienced regular access in 1995 or before. Of the students who had regular access, 17 students first experienced Internet access at home. Students who did not have home access experienced Internet access for the first time at school. When asked about their experience using the Internet, the majority of students indicated that they had been using the Web for more than five years. When connecting to the Internet, 6 students used the campus network, 12 students used a personal DSL or cable modem, and 2 students used a dial-up service.

Overall, these students clearly reported that they were familiar with using computer technologies daily for school, work, and personal activities. Considering the demographics of this classroom, these results demonstrate that the majority of these students lived in homes and communities that at least provided, if not actively encouraged, opportunities for technological literacy as a precondition for academic, social, and economic success. In this sense, the majority of these students have lived with

the initial conditions of computer access. Therefore many of the difficulties that Haas, Matsuhashi, Bridwell-Bowles and others reported about the unfamiliarity of computer use for writing does not appear to frustrate, intimidate, or inhibit writers' achievements, but the majority of these students found computers as a generative tool that enhanced their learning and writing.

Three Voices: The Composing Processes of Three Student Writers

All three case study subjects were Colorado residents who lived off campus. The economic situation of each participant was very different. People from different social classes have different forms of adversity that they must overcome to succeed in the classroom at the college level. None of the case study participants had any noticeable physical or mental handicaps and they did not admit to any visual, mental, or psychological disorders. For the purposes of this study, I assumed that physiologically these three students were healthy average college students.

All three students were strongly influenced by family members and the communities they grew up in, which they all cited as having a dramatic impact on their desire to pursue a degree in scientific fields. Overhearing multiple student conversations during the semester, as students discussed their motivations for selecting, researching, and pursuing their field of research was typically due to a significant event or person in their lives that encouraged them to pursue the sciences. For example, Emily wanted to attend to graduate school to study cancer cells and microbiology because cancer cell mutations and progressions intrigued her while she also feared for her father's life when doctors diagnosed him with cancer. Dan grew up on the Western Slope of Colorado near

the San Juan Mountains with a father who loved to hunt, fish, camp, and explore, enjoy, and preserve the wilderness. Dan's connection to his father planted the seed for a fascination with wildlife leading into his major in Wildlife Biology and aspirations to work for the Division of Wildlife. Similarly, Ashley originally wanted to become a veterinarian because she grew up with animals and her parents encouraged her interest in medicine. According to their interviews, these significant events dramatically focused these student's career interests, which I suggest represents a sensitive dependence on initial conditions.

Younger generations continue to adjust to technological innovations and apply these resources to their writing processes. When considering the frustrations and struggles that Haas, Matsuhashi, and Bidwell-Bowles and others have proposed, the majority of these students feel empowered by computers and regularly multi-task and switch between multiple windows and programs as they write. None of the case study participants adjusted the chairs, lighting, or monitors and none of them complained that they could not get a "sense" of their texts from reading them on a computer screen. All three students made minor adjustments to the position of the keyboard and mouse. Fifteen students responded that they switch between multiple windows and programs often or very often while writing. This should not be surprising because the process is similar to a writer switching between notes, a dictionary or thesaurus, a textbook, and their written text; however computers offer quicker access to more resources than most students would normally have on hand. This process of switching between tasks is perhaps one of the most generative aspects of the writing process through which complexity and chaos may

provide further insight. In the remainder of this chapter, I attempt to paint a picture of the writing processes and influences for Ashley, Dan, and Emily.

Ashley

Ashley was a 21-year-old senior graduating with a degree in Zoology, but was planning to return to CSU in the fall to take some additional prerequisite courses so she would be accepted into a nursing program the next year. She originally came to CSU wanting to become a veterinarian because she liked animals, growing up with three cats and two dogs and currently living with one cat and one dog, and she admitted that she did not like working with people. Ashley explained her decision to switch her career to nursing during the second interview.

Um, originally, I thought I didn't like people, (laughing) not like I don't, but I felt like I didn't deal with them very well, that played a huge role because I've always loved the medical side of things, but after working in a couple of clinics where I was actually in roles where I dealt with clients, on a more one-to-one basis, after I talked with them, I thought "well, that wasn't so bad."

Ashley grew up in an affluent household in Colorado Springs with both parents. Her parents always encouraged Ashley to go to college after high school. Her parents paid for all of her educational and living expenses plus extra spending money. Taking 16 credit hours and working 10 to 12 hours per week CSU Veterinary Clinic, Ashley did not feel that she had much free time for hobbies and other activities, but periodically throughout the week and on most weekends, she spent some time with her boyfriend.

Ashley first used the Internet at home in 1991. She had broadband access at home and she typically wrote in the same location in a CSU computer lab. She used the Internet about six hours per week, owned one computer at home, and when she was online, she predominately used the Internet for e-mail, research, and surfing the web. Other minor activities included IM and keeping up with current events and the news online. She said it was hard to estimate how much time she spent doing each activity because she did multiple activities at the same time. Both of her parents earned baccalaureate degrees and her parents' annual income was between \$95,000 and \$110,000. Ashley remembers her mother teaching her and her brother how to write.

My mom is more, like, she is the better writer out of my mom and dad, so she was the one who was always helping my brother and I with writing. She said that I always liked words when I was little, I wanted to know what they were and how to spell them and everything like that...I'm not the world's greatest speller, but I liked them anyways. I guess when I was in elementary school, which was in Idaho, we did the phonics stuff, and so that is primarily how I was first taught, with phonics, but I've always been a good writer, but I don't like it as much as working with animals.

During the school week she typically gets 7 hours of sleep and 8-9 hours on the weekends. She estimated that she spent 18 hours preparing her second portfolio and usually wrote for 4 hours at any one time. She typically wrote during the evening from 5 p.m. until 10 p.m. She communicated with a classmate once outside of class about her writing and twice with the instructor. She preferred to communicate with people face to face. She strongly agreed with the statement that she consumes caffeine and eats while

writing. She occasionally switched between different windows and programs while writing. She listens to music while writing very often. These can be considered some of the initial conditions through which Ashley approaches writing and her personal history which has shaped and influenced how she writes.

Portfolio 1

Ashley wrote two pieces for her first portfolio project. The first piece was a text analysis written for science writers to “demonstrate how the type of audience influences how information is written and portrayed within a publication.” Table 4.3 illustrates the development of this text through the writing process as she gradually added to and revised her essay. Complex systems are prevalent enough that they even appear in Ashley’s essays as she described articles related to the carbon cycle where a center pullout graphic provided, “a different perspective on how everything is connected and if something is “turned” just a little different, it will affect how the rest of the system “turns.” She also writes, “These pictures show how there is balance in the world, but they also paint a picture of how a shift in our global temperature could tip the scales against us and upset the precious balance that now exists.” Ashley’s second piece illustrated the importance of visual rhetoric for writers and editors of general interest publications to capture and maintain reader interest. Ashley completed more drafts, added more material, and revised a greater percentage of the overall text between drafts than the other two writers in this study revised.

Table 4.3 Ashley Portfolio 1 – Text Analysis: Writing to different Audiences

	Draft 1	Draft 2	Draft 3	Final Draft
Pages	5.5	5.5	6.75	6.75

Headings	0	0	3	3
Paragraphs	6	6	12	12
Sentences	60	62	76	76
Total Words	1718	1726	2142	2146
Average Sentence Length	28.6	27.8	28.2	28.2
Median sentence length	28	26.5	27	27
Mode sentence length	19	19	25	25
Shortest Sentence*	6	6	6	6
Longest Sentence	53	53	53	54
Reader(s)	Emily	Madison / Ashley	Ashley	Madison
Comments	78	21/15	18	27
Local comments	76	9/10	18	19
Global comments	2	12/5	0	8
Text changes from previous comments		100 %	93.3 %	100 %

* Sentence fragments counted as sentences

Table 4.4 Portfolio 1 – Anthology – Visual Rhetoric

	Draft 1	Draft 2	Draft 3	Draft 4	Final Draft
Pages	4	6	6	6	6
Headings	0	0	0	0	0
Paragraphs	7	8	9	10	13
Sentences	53	88	83	82	83
Total Words	1253	1976	1844	1888	1898
Average Sentence Length	23.6	22.5	22.2	23	22.9
Median sentence length	24	22	22	23.5	23
Mode sentence length	30	24	10	24	24
Shortest Sentence*	1	1	1	1	1
Longest Sentence	45	49	49	58	60
Reader(s)	Emily	Madison / Mike	Susan	Madison / Ashley	Madison
Comments	16	22/19	37	22/37	20
Local comments	10	15/15	30	15/37	15
Global comments	6	7/4	7	7/0	5
Text changes from previous comments		76 %	89.8 %	31 %	100 %

* Sentence fragments counted as sentences

Ashley expressed an initial struggle to get back into the habit of writing since she had not written regularly since her freshman composition course. Ashley found it difficult to imagine an audience besides her professors who would be interested in reading what

she had to write. She said that she tended to write in the evenings after she had finished all of her other homework because she worried more about her major classes and wanted to work on them when she had more energy. Therefore, she typically consumed caffeine to stay awake at nights to write. Ashley said that she did not usually write outside of what she was required to for school because she was busy and only really wrote in a journal when she was really stressed and needed to express her thoughts to “clear” her head and “hopefully see things clearer.”

Ashley preferred writing on computers because of the ease of adding and deleting sentences and she rarely wrote by hand: “although I do think during the revision process it greatly helps to work from a print out and make corrections on paper and then go back to the computer.” She explained that she found it easier to make comments and revisions on a hard copy rather than the computer screens because she found that she would catch mistakes in print that she would miss on a screen and she liked the visceral and tactile sense of text in print and the ability to visualize the text as a whole. The only resources Ashley used while writing were a physical dictionary and thesaurus to check on word spellings and synonyms.

Ashley describes herself as a multi-tasker: “I have been known to eat, drink, listen to music, and talk on the phone while I am writing, depending on where I am. But talking on the phone doesn’t work as well. (laughs) And I have to stop writing because I can’t form two sentences at once in my head very well.” However, Ashley said that she could sing along with a song that she knew well and write at the same time because, “they don’t require the same thought process.” If she is not familiar with the song, then it becomes background noise and she claims that she is able to filter it out of her thoughts easily. The

only other distractions Ashley mentioned that she experienced was at home when her cat would jump up on the desk, keyboard, or her lap while she was writing, but she said that she was used to the periodic intrusion from time to time.

Observations and statistical analyses performed using *Inputlog* and parsing video recordings of Ashley’s writing sessions clearly separate her from the other two students in this study in terms of the number of times she switched tasks while writing. The task switches described through *Inputlog* only describe the number of switches between keyboard usage and mouse usage, whereas, the video switches differentiate between all of the activities described in Table 4.5.

Table 4.5 *Inputlog* Writing Session Statistical Analysis

	Writing Session 1	Writing Session 2	Writing Session 3
Words	467	167	419
Average Word Length*	5.4	7.0	6.4
Sentences	16	4	16
Paragraphs	3	1	2
Task Switches	334	274	184

*Word length is given in terms of characters

Table 4.6 Writing Session Video Observations

	Writing Session 1	Writing Session 2	Writing Session 3
Reading	34.67 %	38.08 %	28.00 %
Typing	38.17 %	19.22 %	35.97 %
Notes	21.28 %	12.64 %	22.97 %
Highlighting	2.81 %	1.86 %	1.06 %
Scrolling	1.92 %	0.81 %	0.86 %
Internet	0.0 %	6.36 %	0.0 %
Other	1.17 %	21.03 %	11.14 %
Task Switching	370 times	313 times	444 times

Ashley adjusted the keyboard at the beginning of every writing session. She shifted her body position in the chair, on average, every 7 minutes. As Table 4.6 shows, Ashley often switched between the tasks of reading, typing, scrolling, and reviewing

notes. During the first interview, Ashley said that she did not think that she had changed any of her writing habits since arriving at college. “I’ve always been a procrastinator and I still don’t like peer editing very much.” However, at the end of the semester, Ashley said that she did not put writing off as much as she did before COCC301B and she understood more of the value in peer editing and helping her to focus her ideas for clarity. Ashley preferred to read her text aloud afterwards to “check her writing for grammar and flow.” She realized that after working on a text for a long time, she would automatically fix mistakes in her head and forcing herself to read it aloud helped her to catch more mistakes.

Ashley had not used the CSU Writing Center and neither had any of her friends. She said that she only had other people edit her papers if she was done early, which was a rare occurrence. She said that besides her teacher, the only other person she had read over her papers was her mother, because her mother was an elementary school English teacher and she trusted and valued her comments. Ashley also preferred to have her mother read her papers because her mother was already familiar with her writing style.

As far as dealing with mental distractions, Ashley said that sometimes when she was writing she thought about other things she would rather be doing like watching TV or sleeping. Otherwise, she said that she did not struggle with maintaining her focus on the writing task.

Her voice and sarcasm for the piece speaking to writers and editors for general publications came while she was writing late at night and tired and feeling sarcastic about what she was writing. The next morning, when she read back over what she had written, she revised some of the “drier parts” in the rest of her paper to use the same tone

throughout. She did not continue writing her paper late at night again, but she imagined the voice she used when she was tired and incorporated it into the rest of the paper.

Ashley believed that people were born good writers rather than developing into good writers, but she also thought writing could be learned. She disagreed that practice was the most important part of being a good writer. She considered herself a good writer, but she did not enjoy writing. She was not excited about learning about how computers work, but she felt confident in her ability to learn and use computer programs by strongly agreeing that computers are necessary tools in both educational and work settings.

Portfolio 2

Ashley's second portfolio project focused on recent changes for animal vaccination schedules. Her first piece was a short pamphlet for pet owners to reference when they visited their local veterinary clinic. While discussing topic ideas for Portfolio 2, Ashley originally wanted to write about heart disease, but after a conversation with Madison, she decided to focus on vaccination protocols. In her online posting for her final reflections Ashley wrote, "The biggest influence on my writing was my own personal desire to learn more about this subject. I knew that if I could be confused on vaccination protocols and I worked at a veterinary clinic, most likely owners of pets were just as confused if not more." During the second writing session, Ashley was tired because she slept for only five hours the night before and she was stressed by important tests and projects that were due soon in several other classes.

Ashley sat next to Emily in class and they often worked in the same group and reviewed one another's papers throughout the semester. Ashley incorporated more of

Emily’s suggestions for her writing than the suggestions she received from other students. For example, considering all of the drafts that Ashley wrote for both portfolios, Ashley had Emily edit five out of eight drafts critiqued by other students. As Tables 4.3, 4.4, 4.7 and 4.8 show, Ashley made approximately 85 percent of the total number of changes Emily recommended. Compared to only 68 percent of changes from comments made by Adam and 31 percent of changed recommended by Susan, it is clear that Ashley valued Emily’s comments more than the other students’ feedback. The only person whose comments Ashley appeared to pay more attention to for her portfolio was Madison.

Table 4.7 Portfolio 2 – Vaccination Protocols for a Veterinary Clinic Brochure

	Draft 1	Draft 2	Draft 3	Final Draft
Pages	2.5	3.5	3.5	2
Headings	1	5	5	5
Paragraphs	7	10	10	16
Sentences	35	41	43	43
Total Words	691	853	880	880
Average Sentence Length	19.7	20.7	20.5	20.5
Median sentence length	18.5	20	20	20
Mode sentence length	17	20	19	19
Shortest Sentence*	9	9	9	9
Longest Sentence	38	34	34	34
Reader(s)	Emily	Emily	Madison	Madison
Comments	40	14	21	21
Local comments	26	13	12	12
Global comments	14	1	9	9
Text changes from previous comments		95 %	85.7 %	85.7 %

* Sentence fragments counted as sentences.

Ashley’s second piece explained the changes in more depth for cat pet owners and readers of *Cat Fancy* magazine. Ashley received most of her feedback from Emily, with two drafts also edited by Susan and Jacob. She did not always incorporate all of the comments people gave her, especially when it came to word choice, but Kate made a comment about a word choice on her final draft that other students suggested to change.

She did not ever have Kate look at her second portfolio drafts because she did not have time to complete the drafts early enough to give to Kate in a form which she felt appropriate for her to receive feedback.

In many cases, she made the majority of the changes and recommendations she received from others on her work and tended to leave the parts that were not commented on alone. Although some of the percentages shown in the drafts may seem low, some corrections were not made until later drafts. Some changes were made as a result of the comment but did not exactly follow the comment's advice; therefore, that comment was not included as a direct change following the verbatim feedback, which demonstrated some ownership and thought by the author for their personal voice, style, and judgment in their writing.

Table 4.8 Portfolio 2 - Vaccination Protocols Article for *Cat Fancy*

	Draft 1	Draft 2	Draft 3	Draft 4	Final Draft
Pages	0.5	4.25	4.33	11	12.5
Headings	1	4	5	7	8
Paragraphs	2	14	14	26	35
Sentences	10	59	63	133	166
Total Words	146	1188	1250	2881	3678
Average Sentence Length	14.6	20.1	19.8	21.7	22.2
Median sentence length	12	19	20	21	21.5
Mode sentence length	11	14	20	23	18
Shortest Sentence*	2	3	3	3	3
Longest Sentence	32	42	41	41	41
Reader(s)	Ashley	Jacob	Emily	Ashley	Madison
Comments	17	32	15	44	21
Local comments	5	31	12	42	17
Global comments	12	1	3	2	4
Text changes from previous comments		91.3 %	72.6 %	89.8 %	90.9 %

* Sentence fragments counted as sentences.

At the beginning of the semester Ashley typically waited until the last minute to write for classes, but at the end of the semester she said that she planned ahead more

often and worked ahead regularly for this class. The most significant lesson she learned from 301B was how to write for general audiences with little background knowledge about a scientific topic. At the end of the semester, Ashley's survey responses expressed that she was tired of writing and wanted to avoid writing. She changed her opinion from agreement to disagreement that practice was the most important part of being a good writer. She was less confident that writing could be taught and that good teachers could help her to become a better writer. However, at the beginning of the semester, she strongly agreed with the statement that she was not a good writer and at the end of the semester, she strongly disagreed with that same statement.

Despite all of Ashley's hard work during the semester, she felt despondent about what she learned from COCC301B. She did not think that it would be very relevant for her in the future, because she predicted that she would not be writing for general audiences. Ashley posted the following comments on the class discussion forum for her final reflection on the course:

Unfortunately in my field (Biology-Zoology), journal articles by major research groups are all that are considered acceptable and valid research. I think too often the media has tainted science and it is now fairly un-trusted by the scientific community. With writing for this field you must research your topic by looking up journal articles and then include their ideas in your paper.

According to her postscript for the second portfolio, Ashley did not feel that any of the beginning of the semester discussing the relationships between readers, writers, topics, and context influenced her final products for the second portfolio. However,

interestingly, she spends the majority of her first portfolio pieces describing the importance of how different rhetorical devices, lexicons, contexts, and audiences influence how writers present similar information to fit their purposes and perceived audiences. Ashley even adapted her own brochure and magazine article with visual elements, breaking paragraphs into smaller sentences, explaining scientific jargon in “layman’s terms,” and attempting to adopt a voice, style, and arrangement for each piece. While she may not have felt like she had learned much from the beginning of the course, I would argue that she probably would not have been able to write as well as she did without that portion of the course from the evidence of the changes in her writing style and process over the course of the semester. She noticed that her writing process changed over the semester because she found herself asking more questions about what her audience would want to know and the best way achieve her purpose, which she did not do as often before taking the course.

Dan

Dan was a 25-year-old guest student junior majoring in Wildlife Biology. He usually appeared tired and stressed during each writing session. He was struggling to find a way through school academically and financially, his divorced parents were supportive and willing to make significant sacrifices to help him through school. Dan had to deal with more chaos than either Ashley or Emily because he was laid off, moved in the middle of the semester, and struggled to pay back school debts. Dan’s hopes were to graduate from CSU and go work for the Department of Wildlife, but knowing the steep competition for positions and his academic record, he remained uncertain about what he

would do after college. If he was unable to find a job in his field, he speculated that he might go back to Montrose to do some landscape surveying work with his father.

Both of his parents earned associate's degrees and he wanted to earn his baccalaureate degree and possibly continue to get a master's degree. As a guest student, CSU allowed Dan to take only six credits. Compared to Ashley and Emily, Dan communicated the most often with classmates and Madison outside of the classroom. Dan e-mailed classmates 5 times during the semester, and he e-mailed Madison over ten times. Dan preferred to speak to other students in person because it is faster and easier to communicate more information in less time, but he preferred to use e-mail with Madison because of his discomfort with authority figures in individual settings.

Dan first experienced regular Internet access at school, and he accesses the Internet most often at CSU. Dan did not own his own computer and estimated that he averaged using the Internet for three to five hours each week. At the beginning of the semester, Dan wanted to learn more about writing, but he usually procrastinated with his writing homework and rarely wrote outside of school related assignments. He considered himself a good writer and almost never used a pen and paper when he wrote. Dan recognized times during the day when he was more effective as a writer. He typically wrote at the same CSU computer lab in the afternoons and evenings because "writing in the morning is sort of counter-productive" because he knew that he had more time to finish. He said that he would "zone out for a while or find excuses to interrupt production some other way." Although he rarely wrote for personal reasons, he said that he sometimes wrote to vent frustration or to remember a significant event. He said that he

often has some literary ideas in his head, but he does not “have the motivation to actually put them on paper.”

Portfolio 1

Dan wrote three pieces for his first portfolio. The first piece was an anthology analysis that he wrote for 301B students describing “the rhetorical liberties that science writers take in order to make science and technology more fascinating to non-experts readers.” With this piece, he said that his biggest struggle was writing clearly and concisely.

I struggle most with wordiness. I’ll often start out with a sentence that takes up three lines and uses two or three commas. Then I try and slim it down as much as possible. Lately I have focused a lot on active voice, even before we covered it in class. I am trying to achieve quick, aggressive sentences, like Hemingway used. The idea is to spend more time arranging words and using good metaphors instead of exhausting your entire vocabulary to sound intelligent.

Table 4.9 Portfolio 1 – Anthology Analysis: Neanderthals

	Draft 1	Draft 2	Final Draft
Pages	6.25	6.25	7.25
Headings	5	4	8
Paragraphs	15	15	17
Sentences	76	75	89
Total Words	1712	1702	1972
Average Sentence Length	22.6	22.7	22.2
Median sentence length	20	21	21
Mode sentence length	20	21	16
Shortest Sentence*	9	9	6
Longest Sentence	49	49	49
Reader(s)	Madison	Dan	Madison
Comments	13	18	22

Local comments	1	13	10
Global comments	12	5	12
Text changes from previous comments		53.8 %	100 %

* Sentence fragments counted as sentences.

Dan's second piece discussed the balance science writers must maintain between their faithfulness to scientific rigor and entertaining their readers enough so they will read their content. Dan struggled to identify his audience clearly in several of his texts, including this one, where he suggested his general audience was science teachers.

Table 4.10 Portfolio 1 – Text Analysis: Science vs. Entertainment

	Draft 1	Draft 2	Final Draft
Pages	1.5	6.25	6.25
Headings	0	0	0
Paragraphs	5	18	18
Sentences	21	91	92
Total Words	395	1861	1863
Average Sentence Length	18.8	20.5	20.25
Median sentence length	17	20	19.5
Mode sentence length	23	16	16
Shortest Sentence*	1	1	1
Longest Sentence	43	45	45
Reader(s)	Luke	Dan	Madison
Comments	0	0	23
Local comments	0	0	3
Global comments	0	0	20
Text changes from previous comments		0 %	0 %

* Sentence fragments counted as sentences.

Dan wrote his third piece of the portfolio the night before the portfolio was due. Every time we meet he was stressed by many other factors in his life, but he also felt that he worked better under pressure. Dan tried to minimize his distractions by working at school. He felt like he was more productive on campus because he was there only to work on his schoolwork as opposed to all of the distractions available at home such as the television, telephone, refrigerator, and friends.

After Dan received his first portfolio, he said that he wrote the second piece of the portfolio the night before it was due. He was working under stress pressure and invigorated by caffeine. He said that he decided to vent some of his frustrations with the class and he imagined himself going back in time and giving himself advice for how to do well in 301B. Then he decided his audience would be for future 301B students to read his text on the first day of class in order to help them remove misconceptions of the course.

It spoke directly to 301B students and was intended to be read on the first day of class. It was largely autobiographical, illustrating the misconceptions that I brought into this class. My style and voice in the paper were a total 180 from the previous pieces. I was pressed for time, and spoke quickly and to-the-point in the language of my peers. I was also frustrated and sick of this class, and I allowed that to come through a bit. I was pleased with the final result. But I was afraid that Kate would know it was a filler and shoot it down. She probably did realize that it was a last minute deal, but it was far and away her favorite of the three.

Under pressure, he was able to define a specific audience and spoke candidly about his experience in that class and giving advice to students who were going to take that class in the future what to expect. Dan thought that he was going to be marked down severely for writing it because it was “off the cuff” last minute procrastination, but Madison’s comments indicated that it was one of her favorite pieces of the portfolio.

Table 4.11 Portfolio 1 – Advice to future 301B students

	Draft 1	Final Draft
Pages	3	3
Headings	0	0

Paragraphs	8	8
Sentences	55	55
Total Words	941	937
Average Sentence Length	17.1	17.1
Median sentence length	15	15
Mode sentence length	15	15
Shortest Sentence*	1	1
Longest Sentence	42	42
Reader(s)	Dan	Madison
Comments	6	15
Local comments	6	2
Global comments	0	13
Text changes from previous comments		100 %

* Sentence fragments counted as sentences.

Dan only wrote on computers and although he admitted to being a slow typist, he loved the ability to edit and change his texts so easily. Dan readily recognized the material limitations of computer screens that Hass and others discussed. Even with the improved resolution of recent computer screens, Dan still preferred to print out drafts to edit them because he never caught as many mistakes when he read text on the screen. “For me, computers eliminate the need for a rough draft. I edit as I go, for the most part. Everything is a work in progress right up until the end. For some reason, though, I can never proof a paper on screen as well as the hard copy.” He repeated this struggle in his advice for future 301B students when he wrote: “The best way to check your flow is to print and read the hard copy. Computer screens are deceptive, somehow masking those obvious mistakes that make you sound like you flunked out of *Hooked on Phonics*.”

Dan preferred not to have other people review his work because, from his experience, he felt that it was a waste of time because people offered bad advice or they were only writing comments because they felt like they were obligated and therefore their

comments were superficial. Before the semester began, he was so frustrated with previous workshops and peer editing sessions from other classes that he only valued the teacher’s comments on his writing.

Contrary to Ashley and Emily’s experiences, Dan confessed that his mind wandered often. He admitted that many noises, people, or movements distracted him from focusing on his writing. Everything from daily stress and hunger to financial challenges and current relationship struggles “would just pop into” Dan’s mind as he wrote. As opposed to Ashley, who preferred to switch rapidly back and forth among different tasks, Dan tended to switch much less between activities and tried to stay focused on one task for a longer amount of time. He described himself and his preferred writing environment by saying, “I’m not much of a multi-tasker at all, so I try to maintain a sterile writing environment. Yeah, writing or studying at home for me is damn near impossible. I seem to get a lot more done at school... I am very easily distracted.” He found these distractions to be productive at times because, “sometimes, when my mind goes on tangents, ya know, I start thinking about other ideas, like stuff and examples that may not really have anything to do directly with what I am talking about, but sometimes they help me come up with a catchy one-liner, a great metaphor, or even a bit of humor that connects with a reader.” Dan loved to listen to music, but he often found it distracting while writing.

Table 4.12 *Inputlog* Writing Session Statistical Analysis

	Writing Session 1	Writing Session 2	Writing Session 3
Words	476	450	385
Average Word Length*	5.5	5.6	5.8
Sentences	20	12	16
Paragraphs	5	5	5

Task Switches	113	156	122
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*Word length is given in terms of characters.

As Table 4.12 shows, Dan wrote a significant amount of text, but many of the words he wrote were different versions or synonyms. He would write a sentence multiple times, using different diction, metaphors, imagery, or syntax, and then he would select his favorite iteration. During each observed writing session, Dan worked on one text and only used the Internet to look up definitions and synonyms from an online dictionary. Dan switched the least number of times between activities out of the three students and his shifts were very deliberate.

During the first writing session, he worked on his anthology piece. For the second and third sessions, he worked on his text arguing against efforts promoting wolf reintroduction into Colorado. Dan spent the majority of the time during writing sessions reading over what he had written and drafting new material. He claimed that he did not have any specific subordinate goals or outlines of his ideas; he simply thought about his purpose and different ways to express his support to achieve that purpose.

Table 4.13 Video Observations from Dan’s Writing Session

	Writing Session 1	Writing Session 2	Writing Session 3
Reading	39.23 %	36.77 %	36.50 %
Typing	46.26 %	45.43 %	31.89 %
Notes	6.87 %	0.13 %	12.25 %
Highlighting	1.88 %	4.22 %	1.69 %
Scrolling	0.52 %	0.06 %	0.28 %
Internet	0.0 %	3.07 %	2.42 %
Other	5.24 %	10.32 %	14.97 %
Task Switching	228 times	258 times	239 times

Dan also explained that many times he would think about different ways to approach his writing and brainstorm over a period of days or weeks because, “you never

know when you'll have a great idea about what to write next. I mean, there is a lot of brainstorming that goes on during my writing process anyways. And it seems like ideas often pop into my head while driving or walking around campus.”

Portfolio 2

For his second portfolio, Dan wrote two pieces related to endangered species in Colorado. The first addressed the search for the Northern River Otter’s population size and existing habitat. Dan struggled with this piece because his audience and purpose were not very well defined. He did not declare to whom he was writing and he handwrote the purpose on the final brochure draft, as if the purpose was an afterthought. In his interviews, he repeated how disappointed he was with the otter piece because he had trouble figuring out what to write.

Table 4.14 Portfolio 2 – Otter Brochure

	Draft 1	Final Draft
Pages	4	4
Headings	3	3
Paragraphs	9	8
Sentences	39	36
Total Words	756	695
Average Sentence Length	19.4	19.3
Median sentence length	19	19
Mode sentence length	14	14
Shortest Sentence*	9	9
Longest Sentence	35	35
Reader(s)	Pat	Madison
Comments	13	11
Local comments	4	7
Global comments	9	4
Text changes from previous comments		65.8 %

* Sentence fragments counted as sentences.

Dan's strongest piece was a project that he threw himself into spending hours researching and thinking about his argument, his audience, and his objectives for his piece. The topic of wolf reintroduction was an issue close to his childhood home. He argued against wolf reintroduction in Colorado by informing the reader of the wolf's imminent arrival and strong possibility of wolves already inhabiting the state.

Table 4.15 Portfolio 2 – Wolves Reintroduction Article

	Draft 1	Draft 2	Draft 3	Final Draft
Pages	1	5.5	7.5	11.5
Headings	0	3	4	4
Paragraphs	3	15	21	32
Sentences	16	71	101	148
Total Words	313	1497	2138	3120
Average Sentence Length	19.6	21.1	21.2	21.1
Median sentence length	20.5	21	22	21.5
Mode sentence length	19	22	23	22
Shortest Sentence*	8	7	3	3
Longest Sentence	32	46	46	46
Reader(s)	Jennifer	Peter	Dan	Madison
Comments	2	2	23	15
Local comments	0	0	22	14
Global comments	2	2	1	11
Text changes from previous comments		100 %	100 %	87 %

* Sentence fragments counted as sentences.

I was aware that my position as researcher in investigating Dan's writing process had an impact on him because many of the questions I asked him during the interviews caused him to reflect more on the focus, techniques, and style of his writing than he would have normally considered. In this way, I was able to see into what areas of his writing he focused on and what areas he neglected to explicitly address. For example, in several interviews I briefly discussed various literary techniques and he incorporated

some of those in several of his texts. Dan utilized metaphor and attempted humor and wit more than either Ashley or Emily.

By the end of the semester, Dan's overall attitude about writing increased in nearly every area. He changed his opinion from disagreeing with the idea that writing could be taught to agreement with that statement. He even strongly agreed that he enjoyed discussing his writing with other people. Dan's attitudes about computers did not change throughout the semester; he was confident that he could use them and that they were necessary for work and school, but he was not excited to learn more about computers than what he already knew.

In a sense, Dan represents a sort of phase transition, or at the edge of chaos in his writing. Chaos in the sense of being fatigued, invigorated with caffeine, functioning under time pressure, with additional economic and relationship issues creating social turbulence in his life, was a generative force in his writing. When asked if he prefers chaos, time pressure, and uncertainty to order, more time, and predictability he said, "I work better under pressure, you know, it gives me that extra incentive, that edge, where it is live or die. When I get on campus I know in my head that it is go time." Dan preferred to be under stress with deadlines and unpredictable writing schedules because he felt that it helped to motivate him to get the work done. "I don't enjoy it, but it works. When I have too much time to do something, I end up not getting anything done, because I am always thinking to myself, oh , I have all of this time to get it done."

Emily

Emily was a 22-year-old senior graduating in Microbiology. She lived in an apartment with her fiancé two blocks from campus and that is where she did most of her homework and writing. Her mother was an elementary school teacher and her father was a lawyer. Her passion for microbiology emerged in high school when doctors diagnosed her father with cancer. She maintained an internship at the CSU Veterinary clinic 10 to 12 hours per week for extra spending money and beneficial work experience related to her academic interests. Her father recovered and she graduated, planning to get married in the summer, and attend graduate school in New York in the fall. Her dream was to become a pathologist and search for improved treatments for cancer cells, specifically leukemia. Emily only used the Internet to research her information for all of her papers. She only went to the library to read the academic journals for her science classes that she could not access online, but she feels comfortable using the Internet because she has been using the web regularly for over 10 years.

Portfolio 1

Emily completed three pieces for her first portfolio. Her first piece written to elementary and middle school teachers was intended to inform teachers of alternative ways to use magazines like *Discovery Kids* to incorporate learning in fun ways.

Table 4.16 Portfolio 1 – Text Analysis: *Discovery Kids*

	Draft 1	Draft 2	Final Draft
Pages	5.5	5.5	5.5
Headings	0	0	0
Paragraphs	11	11	11
Sentences	100	100	93
Total Words	1863	1863	1753
Average Sentence Length	18.6	18.6	18.8
Median sentence length	17.5	17.5	17

Mode sentence length	17	17	17
Shortest Sentence*	6	6	6
Longest Sentence	41	41	41
Reader(s)	Steven	Madison/Ashley	Madison
Comments	23	11/28	35
Local comments	21	1/19	33
Global comments	2	10/9	2
Text changes from previous comments		0 %	56.4 %

* Sentence fragments counted as sentences.

Emily struggled to define a clear audience and purpose for her second piece written for “busy moms looking for a good article to read.” Emily’s article primarily focused on rhetorical devices that the author of the article used, but most likely her audience would not be interested in reading about another article and how the author incorporated humor and clear diction. Both Ashley and Madison recommended that she should shift her audience and focus her purpose, but she did not make the larger global changes because she “did not have time.”

Table 4.17 Portfolio 1 – Text analysis: Teen Behavior

	Draft 1	Draft 2	Draft 3	Final Draft
Pages	2.5	3.25	3.25	3.5
Headings	0	0	0	0
Paragraphs	7	7	7	9
Sentences	39	51	51	53
Total Words	736	1068	1068	1079
Average Sentence Length	18.9	20.9	20.9	20.4
Median sentence length	17	20	20	21
Mode sentence length	16	17	17	17
Shortest Sentence*	6	6	6	6
Longest Sentence	40	50	50	35
Reader(s)	Emily	Ashley	Madison	Madison
Comments	0	27	8	28
Local comments	0	16	1	22
Global comments	0	11	7	6
Text changes from previous comments		0 %	0 %	54.3 %

* Sentence fragments counted as sentences.

Emily's third piece was an anthology analysis on several articles related to chimpanzee research and the treatment of chimpanzees after the research was completed. Emily spent the least amount of time on this piece and she said she felt confused about the assignment and tried to write enough to meet the minimum requirements for the portfolio.

Table 4.18 Portfolio 1 – Anthology Analysis: Chimpanzee Research

	Draft 1	Final Draft
Pages	3.5	4.5
Headings	0	0
Paragraphs	6	6
Sentences	58	74
Total Words	1162	1489
Average Sentence Length	20	20.1
Median sentence length	19	18
Mode sentence length	23	18
Shortest Sentence*	5	4
Longest Sentence	49	41
Reader(s)	Steven	Madison
Comments	16	18
Local comments	15	7
Global comments	1	11
Text changes from previous comments		18.7 %

* Sentence fragments counted as sentences.

Emily preferred to write with background noise because she said that she had a hard time concentrating when it was too quiet. For example, she preferred to have the television on in the other room even if she was not watching it or paying any attention to it. However, she did not like to have music on because if she heard a song that she liked, she would begin singing along and the music would distract her too much. The only other

distractions she recognized in her environment were receiving IMs or e-mails from friends and family.

If an email pops up, I will check it only if I am not on a roll. When I am on a roll, I usually stop for nothing until I am done, but if I am having trouble writing, I tend to do lots of other stuff which only makes it take longer.

The only time I need it quiet, or mostly quiet, is when I am reading it over and revising my paper.

Emily thought that her writing process had not changed since high school except that she has gotten worse at writing because she has been out of practice.

Both Emily and Dan preferred to revise and edit their papers as they wrote. Emily would write and rewrite a sentence several times until “it sounded exactly how [she] wanted it to come out.” However, unlike Ashley and Dan, writing was more difficult for Emily when she was at school or in a computer lab. She felt like she was more comfortable and productive when she wrote at home.

Table 4.19 Inputlog Writing Session Statistical Analysis

	Writing Session 1	Writing Session 2	Writing Session 3
Words	137	256	478
Average Word Length*	6.2	5.7	5.4
Sentences	4	5	18
Paragraphs	8	5	28
Task Switches	250	182	184

*Word length is given in terms of characters.

Table 4.20 Video Observations from Emily’s Writing Sessions

	Writing Session 1	Writing Session 2	Writing Session 3
Reading	53.97 %	25.58 %	24.83 %
Typing	17.08 %	20.56 %	29.89 %
Notes	8.03 %	11.47 %	3.69 %
Highlighting	6.39 %	3.22 %	2.03 %
Scrolling	5.44 %	4.81 %	4.67 %

Internet	0.0 %	26.22 %	28.78 %
Other	9.08 %	8.14 %	6.11 %
Task Switching	309 times	254 times	241 times

Portfolio 2

Emily originally wanted to write several articles for the *Discovery Kids* magazine related to the same topic. After several conversations during class with Kate and Ashley, she decided to write a children’s book describing what life is like for a child with leukemia and her second piece was a brochure for parents whose child was recently diagnosed with leukemia.

Table 4.21 Portfolio 2 - Children’s Book

	Draft 1	Draft 2	Final Draft
Pages	4	4	4
Headings	0	0	0
Paragraphs	21	23	23
Sentences	82	94	94
Total Words	898	1048	1049
Average Sentence Length	10.9	11.1	11.1
Median sentence length	10	10.5	11
Mode sentence length	10	10	10
Shortest Sentence*	2	4	4
Longest Sentence	23	22	22
Reader(s)	Steven	Susan	Madison
Comments	11	7	4
Local comments	6	7	2
Global comments	5	0	2
Text changes from previous comments		81.8 %	0 %

* Sentence fragments counted as sentences.

Table 4.22 Portfolio 2 – Parent’s Leukemia Brochure

	Draft 1	Draft 2	Draft 3	Final Draft
Pages	11.25	11.5	11	11
Headings	8	8	8	8
Paragraphs	38	38	35	34
Sentences	230	235	217	211
Total Words	3270	3428	3237	3161
Average Sentence Length	14.2	14.6	14.9	15

Median sentence length	13	14	14	14
Mode sentence length	12	12	14	14
Shortest Sentence*	5	5	5	5
Longest Sentence	35	35	34	34
Reader(s)	Ashley	Ashley	Madison/Ashley	Madison
Comments	27	3	14/36	33
Local comments	21	1	4/29	20
Global comments	6	2	10/7	13
Text changes from previous comments		77.8 %	66.7 %	72 %

* Sentence fragments counted as sentences.

In general, Emily’s writing demonstrated more of what Bereiter and Scardamalia describe as knowledge telling. As Madison’s comments indicated, Emily’s focus and development of her texts were more focused on expressing her knowledge about the topic, rather than trying to transform the reader’s understanding of that information through interpretation and associated meaning. Emily’s focus also tended to focus more on summarizing the information in the articles as opposed to analyzing the rhetorical devices that the scientific writers used in writing the texts, which was the focus of the first portfolio assignment.

Emily typically gave the same draft to multiple people to get their feedback and then made primarily local sentence level changes to her final draft. She reconstructed very few sentences and added little information to her drafts compared to her first rough drafts. When asked why she wrote this way, she responded that, “I don’t know (laughs), I guess that is just the ways I always write. I write a lot at one time and then, uh, I look at the comments and see if they are worth the time and effort to change things, that is, if I agree with them, and a lot of times I just don’t have the time.”

Discussion

From analyses of three students' texts, when making final revisions, all three students appeared to refer to one or more of their previous drafts for comments and notes to incorporate into their final drafts. All three students made changes between drafts intermittently – typically local corrections were the most readily corrected, but some global changes took some time and were not made until later revisions because of time constraints or uncertainty about how to proceed. The most generative comments and feedback during the workshops and from the instructor tended to be the global comments which asked questions related to more detail, support, and clarification. However, most students comments tended to focus on the local sentence level grammar and punctuation errors, therefore those were most of the changes that these three students made to their papers from their initial drafts. The phenomenon of students focusing on correcting sentence level errors most likely stems from the prevalence of the current-traditional paradigm in contemporary education, which essentially ingrains the notion in students that correct grammar and punctuation are the vital qualities that result in good writing. However, as Hillocks and others have argued, excessive mechanical instruction does not improve student writing and may actually inhibit a student's ability to compose because they are so focused on sentence level elements that they cannot focus on the important global issues necessary to generate effective content. Sentence level errors are also sometimes easier to recognize and correct, but most of these students seemed genuinely invested in their texts students, therefore I am hesitant to attribute this trend to laziness or apathy. Global comments concerning organization, style, and support

Ashley was the most organized and focused in her writing approach and tended to multi-task as she wrote. Ashley adapted to her surroundings. While some may interpret

her shift from veterinary medicine to nursing as random, she decided to direct her skills, time, and energy into a field with a higher economic demand. Dan was a slow typist and moved deliberately between tasks, took frequent breaks, and incorporated humor or wit into every piece he wrote giving his texts a distinctive voice. Emily tended to be the most productive at infrequent times when she would write the entire draft in one long sitting and then make mostly minor revisions afterwards. Madison tended to write more corrective comments on the students papers who received lower grades on their assignments and more laudatory comments for well-written work. Madison tended to provide feedback and comments related almost equally between local and global issues for all three of these students. While students incorporated specific topics they addressed in class in their workshop interactions, most of the drafts from student portfolios revealed a strong emphasis on local sentence level corrections and much fewer globally focused questions and comments. On the other hand, Madison's comments tended to focus more on global issues and fewer local sentence errors. Madison's commenting philosophy reflects advice she posted in an article for techniques and approaches to effective workshops. In the article "Why Workshop" the author writes, "Concentrate on big issues first. Talk about the overall meaning of the essay, its focus, organization, and support before you get into issues of spelling and punctuation. If problems with large issues lead to major revision, the problem sentences may go away by themselves." Madison's comments from the second questionnaire also discussed several students' writing confidence levels at the beginning of the course, and these perceptions closely correlated to the grades these students earned for this course.

One of the greatest challenges of the class, as Madison pointed out, was getting students to write for a more general audience and not a teacher or group of experts, because the majority of scientific students have had little to no experience attempting this type of task. The majority of their previous experience in writing has been with lab reports and writing for one type of audience, teachers, academics, and experts in their respective fields.

All writers have a writing history, rules, metaphors, models, and authors from which they have adapted their personal writing styles. This process is unique for all writers for every text they ever write. I suggest that this is because writing is a complex adaptive process, where writers learn from their past to adapt their writing style for future writing tasks. For example in her first portfolio, Emily struggled with using the correct agreements between singular and plural forms of different genders. In the third draft of her second portfolio, she recognized and attempted to fix this problem by using the “he/she” construction and Madison recommended using the plural form. Madison made a comment on her portfolio about making sure they agree and then Emily used a more awkward construction in the second portfolio to attempt to fix that problem. This example shows how the writing process functions from a history. As Gell-Mann and Holland have described complex adaptive systems, these systems behave according to previous models, rules, and experiences, the mind attempts to predict how to write a similar sentence in the future. These systems do not always make correct models or accurate predictions. In the writing process, it appears that students who construct models of written texts that most accurately mimic their instructor’s model are more successful in the writing classroom.

Ashley embodied the tenacity required to understand difficult subjects when she writes about how graphics are helpful for science writers for general audiences because, “the graphics help explain in simplistic terms very complex cycles, and if the author were to try and explain a “thermohaline circulation” pattern through words most of the readers would have stopped reading the article immediately due to the utter complexity of it.”

The ability of graphic and visual representations of complex systems is one of the principle reasons why scientists often attempt to develop models of the phenomena they study. Interestingly, the majority of writing theory I have discussed has attempted to do exactly what Ashley explained as inhibiting people from trying to understand the process, because it is so complex that the ideas, parts and relationships get lost in the attempt to explain the system through words.

Self-Organization

At one level, educators have observed some of the concepts presented through complexity theory in their classes for decades. The notion that students self-organize and that through self-organization, students can achieve more than any student could achieve on their own, comes naturally in many classroom in a commonsensical way. The nature of self-organization in this sense has even become cliché. The key concept here is the notion of self-organization: a process describing how a system can develop a complex and orderly structure from disorder.

The study of complexity began at many stages, but one of the most significant in terms of developing the idea of organization out of chaos came from Ilya Prigogine and Isabella Stanger’s research into the thermodynamics of non-equilibrium systems.

According to Prigogine, disorder does not only destroy order, structure, and organization, but is also necessary for their creation and transformation. In Prigoginian terms, all systems contain subsystems, which are continually “fluctuating.” At any time, a single perturbation or a combination of fluctuations may become so powerful, as a result of positive feedback, that it shatters the preexisting organization. Prigogine and Stengers call this critical moment a singular moment or a bifurcation point. At this point the probability that the system will disintegrate into chaos or leap to a higher level of order or organization, which they call “dissipative structure,” is inherently impossible to determine in advance. This concept raises controversies because Prigogine insists that order and organization can actually rise spontaneously out of disorder and chaos through a process of self-organization.

Generally, the process of self-organization of complex systems works in the following way. Streams of information from the external environment flow into the system. This information will influence the interaction of some of the agents of the system by altering the values of the weights in the network. These agents will pass the information through the system via the connections to local agents who pass the information on again if the information is evaluated as valuable. If a stream of data is present regularly, the system will acquire a stable set of weights that represents that input. If two inputs are regularly present together, the system will automatically develop an association between the two. In other words, each time a pattern of inputs enters the system, it will cause a certain pattern of activity within the system and the system will develop a model for that specific pattern of inputs and its respective output, thus enabling the system to model the environment and make predictions. Taking more of a

psychological approach to defining complex systems, Murray Gell-Mann writes in his book, *The Quark and the Jaguar*, his description of the operation of complex adaptive systems as follows:

The common feature of all these processes is that in each one a complex adaptive system acquires information about its environment and its own interaction with the environment, identifying regularities in that information, condensing those regularities into a kind of “schema” or model, and acting in the real world on the basis of that schema. In each case, there are various competing schemata, and the result of the action in the real world feedback to influence the competition among these schemata. (17)

Gell-Mann also points out that complex adaptive systems can make mistakes in identifying regularities (“Regularities” 55). This possibility explains why even some complex adaptive systems do not survive environmental changes.

Self-organization provides a useful analogy for understanding how collaboration among students occurs. Madison described how one group of four students joined to take advantage of one another’s strengths and as Madison explained in her questionnaire response, “By the end of the semester, that group was almost indivisible, even when I asked for folks to work with peer reviewers who hadn’t seen their papers.” However, in terms of the actual writing process, the concepts of emergence and self-organization go against Bereiter and Scardamalia’s notion of an “executive routine” because the simple interactions of multiple neurons firing creates an ordered process without a central executive controlling the larger operations.

Adaptation

Complex adaptive systems have to persevere within a dynamic environment. Depending on the severity of these changes, great demands can be made on the resources of the system. To cope with these demands the system must have two capabilities: it must be able to store information concerning its environment for future use; and it must be able to adapt its structure when necessary. A prominent feature of complex systems is a rich interactive network of connections between individual agents which operate through a series of feedback loops. The ability to self-organize allows complex systems to develop or change internal structure spontaneously and adaptively in order to endure or manipulate their environment (Cilliers 90). Taylor emphasizes that “[f]or complex systems to maintain themselves, they must remain open to their environments and change when conditions require it. Complex adaptive systems, therefore, inevitably co-evolve with their environments and other integral systems” (156). What is remarkable about a complex adaptive system is that it actively tries to manipulate any circumstance to its advantage, and all without a central executive authority directing the system (Waldrop 11). Species, businesses, and individuals all evolve for improved survivability in changing environments. Even the marketplace responds to changing tastes in lifestyles, immigration, technological developments, shifts in the price of raw materials, weather climate, and many other factors. It is because these complex adaptive systems actively adapt to their environments that complexity theorists argue that these systems position themselves in the most advantageous position as possible, where little energy is necessary

to make large changes necessary to adapt to an unpredictable environment. Chris Langton coined the term for this region that exists far from equilibrium—the edge of chaos.

There is generative order and generative chaos in the writing process. These three students' experiences demonstrate that chaos was most prevalent during the brainstorming and research phases of their processes. Where they struggled is when they were unable to find enough direction and focus (order) in their writing topics pertaining to their audience, purpose, and topic for discussion.

The strange attractors, which seemed most relevant to these students', which emerged from their interviews, texts, and surveys were their time constraints, motivation, and interest in what they were writing. All of these students chose topics that interested them, but interviews and the progression of their texts revealed that they thought about issues of audience, purpose, and means of persuasion throughout the process as opposed to at the beginning of the process to imagine how to frame their topic in a way that they were confident that they could achieve. Strange attractors to the successes and struggles for these students clearly emerged in the students' abilities to narrow a topic, focus their audience, define their purpose, and follow through with adequate time and feedback from peers and the instructor. Another strange attractor in writing could be linked to chaos with respect to a writer's ability to imagine their audience, questions their audience would ask, and to use the most effective combinations of ethos, logos, and pathos to appeal to their readers.

In terms of materiality, access to writing resources could be thought of as an initial condition upon which students' technological literacies and writing abilities

sensitively depend in order to remain competitive with their peers. Computers, websites, e-mails, and online discussion forums are strange attractors, or regions, in the writers' processes to which they return unpredictably but repeatedly through an iterative and recursive process. While the screen size and legibility factors encountered in electronic editing may be amenable to a technical fix, even with the best of monitors readers and writers working online may have to accept a performance tradeoff related to the other two factors Haas identified: responsiveness and tangibility. Fortunately, CSU provided adequate resources for all students to use computer labs and access online resources.

In this study Ashley performed the best in the course, but she also had the most favorable circumstances because she did not struggle financially or with social life changes as Dan and Emily experienced during the semester. At the beginning of the course, several students indicated an interest in participating in the study but doubted their ability to manage enough extra time to participate. Therefore, I know that many other students in the course were dealing with other stressful situations academically and economically.

Although not immediately emerging from these individual writers' processes, this study suggests that this class of students struggled to examine larger global problems and questions in the arrangement and structure of their writing. Too often students focused on sentence level errors instead of the larger global arrangement and overall use of logos, ethos, and pathos. This scenario can be considered an example of the fractal nature of a text where writers become so focused on only one scalar level of their writing that they think is the most important to "good" writing, while excluding all others. In another sense, this example demonstrates how writing is a complex process because these writers

have limited local domain knowledge about what constitutes effective writing patterns and structures while remaining ignorant of global patterns and issues in writing.

No two environments are so similar as to produce such parallel anatomy in the same way that no two classrooms are so similar that they will interact in exactly the same way from one year to the next. Looking back at this study, it would be interesting to research a more culturally, racially, socially and economically diverse classroom to see if differences in student writing processes apply to other demographic populations. As with so many other fields, writing well requires an initial interest, supported by a network of knowledge, sources for feedback, motivation to succeed, and the perseverance to overcome obstacles and resistance.

Success within a particular field, such as composition, requires years of practice and refinement. As Holland wrote, “Many years are spent in acquiring the elements of discipline, and individual differences come into play in important ways. Disciplines are like metaphors: they involve complicated auras that cannot be spelled out in any simple way. “Feeling” for a discipline only comes from constant immersion. Even this does not guarantee success” (212). That is part of the mystery that attends our lack of a well-defined model of the creative processes.

Writing on the Edge of Chaos

Borrowing a metaphor from physics, life may exist near a kind of phase transition. Water exists in three phases: solid ice, liquid water, and gaseous steam. It now appears that similar ideas might provide an understanding of complex adapting systems. Chris Langton found Wolfram’s fourth class of behaviors particularly interesting. He suspected activity in this region would be characterized by “a phase transition between

highly ordered and highly disordered dynamics, analogous to the phase transition between the solid and fluid states of matter” (Taylor 146). He discovered that Wolfram’s four patterns of behavior fall into a regular sequence between order and disorder, depending on the rules governing the interactions, which Langton described as “complex.” That is, between order and disorder lies the realm of complexity or, in Langton’s words, “the edge of chaos.” Summarizing Langton’s conclusions, Kauffman writes: “Just between, just near this phase transition, just at the edge of chaos, the most complex behavior can occur—orderly enough to ensure stability, yet full of flexibility and surprise. Indeed, this is what we mean by complexity” (*At Home in the Universe* 87). Other scholars have observed similar phenomena and used terms such as self-organized criticality (Per Bak), combinatorial optimization (Stuart Kauffman), or the moment of complexity (Mark Taylor). Even Von Neumann recognized that a dynamical system could have points of instability—critical points where a small push can have large consequences. Langton preferred “the edge of chaos” because it evokes images of being poised in space, tentative, dangerous even, yet full of potential, which I suggest may be a useful metaphor for student writing.

Taylor makes a connection between the structure of Bak’s self-organized criticality and Kierkegaard’s moment of decision, which is interesting to contemplate in terms of the writing process. Kierkegaard distinguishes three different forms of life. These stages of life, characterized by different principles governing thought and rules guiding conduct, are separated by gaps where change occurs unpredictably. Since there is no necessary relationship between or among the aesthetic, ethical, and religious forms of life, Kierkegaard concludes that individuals must make a free will decision, or in

Kierkegaard's famous words, "a leap of faith." At the moment of decision, as in the moment of complexity, some possibilities materialize while others dissipate. As possibilities are actualized, new patterns emerge, which both impose new constraints and open new possibilities. As Taylor explains, "[t]hough free decisions are always unpredictable, they are never independent of a certain determinism. Decisions, therefore, are the outcome of the interplay of fate and freedom; circumstances beyond one's control bring one to a crossroads when a decision must be made" (148).

Writing creates a mediating space in which openness and closure, chaos and order, creation and destruction engage each other in a rejuvenating and multifaceted dialectic. When writing is in progress, the emphasis is on the possibilities and freedom of the process—anything may happen, the writer may choose from an infinite array of options, chance perturbations create situations whose outcomes cannot be foreseen. But this openness also undermines authorial control over the text by allowing an audience to interpret the text according to their attitudes, biases, and experiences. When writing is ongoing, it creates an open space rich with latent, unarticulated possibilities. Information flows in from many senses, and it is subject to continual editorial revision, which produces multiple drafts of narrative fragments all across the brain's neural network. Yet writing, especially "successful" writing, produces products—pages, drafts, texts, and books. Once these products exist, in a sense, the space has been closed, the order or the words stabilized. The system still remains open to the readers who interact with the text at different times and at differing levels of analyses and experience. However, digital writing environments are making the writing process even more open and fluid by

allowing texts to be continually revised, edited, and expanded by both the author and the readers.

Chapter Five

Conclusion: A View from the Edge

All writers have their own stories, their own idiosyncrasies and habits for writing. This study presented Ashley, Dan, and Emily's individual stories of their experiences, stories that most people can probably associate with certain aspects of their experiences. This study was a preliminary exploratory investigation into possible fruitful connections into areas that rhetoric and composition do not typically go—scientific theories. Emig, Flower, and Hayes most important contribution was bringing a scientific consciousness into composition research. This scientific consciousness is a sense that the methods of science have brought us greater, more precise knowledge of the field of composition than we had achieved before, and that scientific methods will continue to reveal more knowledge to us; however, this has not always been warmly welcomed. For example, in Laurence Hayden Lyall's response to Marilyn Cooper's proposal for the *Ecology of Writing*, Lyall criticizes Cooper for, "yet another instance of the current model-mania attempting to transform the teaching of writing into the science that it isn't" (357). I would argue that the humanities and the sciences are not mutually exclusive, but represent a reciprocal dialectic relationship of knowing, understanding, and representing the world.

Despite the fact that chaos and complexity tend to be more closely aligned with the sciences, both have struggled to gain wholehearted acceptance by scientific communities as well. A survey of the beginnings of chaos and complexity theory describes an uphill battle of a handful of scholars in many different fields—somewhat outcast and receiving strange looks from their colleagues—seen as wasting their time.

Complex adaptive systems rest between the disciplines and offers insight into nearly every discipline because nonlinear systems surround us in almost every aspect of our lives from the weather and animal populations to the nonlinear and complex nature of our brains and language.

Aspects of both chaos and complexity theory emerged from my research into the writing processes of these three students with elements of both systems interacting throughout the semester. I have attempted to limit my scope to keep the information manageable and comprehensible, but I think it is clear from my discussion that there is much more that can be found within the complex system of writing depending on what scale is being analyzed. Unlike in verbal communication where repetition is encouraged to emphasize important points, verbatim repetition often annoys readers in written texts. The medium through which we receive, analyze, and process information determines which aspects of the message are valuable.

One area of these three students writing processes' that is not congruous with chaos and is the notion that complex behavior can emerge from a small number of rules. In the context of this 301 class, writing, language, and science have a large number of rules and conventions which govern what is considered acceptable, reliable, valid, and scholarly in terms of evidence, sources, lexicon, and content. In this context, the writing process is not a system where complex behavior emerges from a small number of rules; however, these rules and conventions have all been social constructions that have developed over time and are not necessarily naturally defined spaces for writing. Again, it depends on the level of scale that the writing process is interpreted. When viewed in terms of a simple writing assignment with only a few requirements, the outcome can be

surprisingly complex. With only a small initial nudge to write about anything from a favorite place to visit, a childhood memory, a dream for the future, or what happened over summer vacation, instructors and peer students can collaborate through meaningful and rich interactions to generate quality writing.

As I have presented through this case study, the edge of chaos presents a generative metaphor and theoretical framework through which composition educators can research and begin to understand the dynamic interactions and influential forces, strange attractors, self-organizing characteristics, and information transfers that affect student writing. There are still so many more questions and so areas in which future research should pursue. While the writing process may be inherently unpredictable, some universal qualities of writing emerge like strange attractors in a given historical and social context that produce effective, creative, and interesting writing. While inherent unpredictability in systems that surround us everyday in the real world may cause anxiety in some, as educators teaching the writing process, we can find some hope in complexity theory when we consider that small differences educators make in the lives of students can have incommensurable qualitative results. One person can make a difference and students can improve in their writing and write surprisingly effective and creative texts given the nonlinear nature of the writing process.

Limitations of the Study

This thesis has several inherent limitations. Trying to interpret specific cases through a radically contingent and idiosyncratic theory, which claims to be generally valid, is potentially problematic. There are elements of the writing process that I was still

unable to analyze because of my personal subjectivities, experiences, and weaknesses. There are many other software applications available that could be beneficial for similar future research. There are computer programs that can conduct content analysis with greater precision for large amounts of text, but these have several limitations mostly associated with human interpretation of the results. There are more powerful screen capturing programs with additional features such as eye-tracking cameras and more intensive analyses; however, these programs also are expensive and beyond the financial resources of this study. This is the first time I have designed, conducted, and analyzed any substantial research and it is prone to be filled with errors.

One of the main weaknesses of this study that I realized after the first couple of sessions was that the amount of time between the writing sessions and the follow-up interviews prevented Ashley, Dan, and Emily from accurately recalling the majority of their thoughts, considerations, and challenges during that specific session. If I were to conduct this study again, I would do a brief interview immediately following the writing session to get their initial impressions, then I would view the session data, and then conduct a follow-up interview within the next couple of days to ask questions about the text. In this case, protocol analysis would have been very beneficial to understand their writing processes. The observations and understandings I gained from the multiple sources of inquiry, while dense, was incomplete because I still missed the real time thoughts, questions, and going on inside a person's head at the time. Despite, this weakness, this study provides a volume of information into these students' writing processes and demonstrates that technology enables innovative ways to reexamine many questions and issues related to the writing process.

Synthesizing Connections for Future Research

As I described the conflicts within the field of rhetoric and composition earlier in chapter two, I think that my presentation of complexity theory as it relates to the writing process embodies intriguing and exciting potential for including many of the generative themes and concepts from other writing theories while allowing for the diversity and dynamic nature of composition. Research in this topic is still too premature to make definitive claims, but we live at an exciting time of rediscovering our world and observing, explaining, and coming to understand the world of writing in new ways.

Understanding the interaction of order and chaos and the resulting complexity gives us a powerful set of metaphors for understanding other complex systems such as the writing process and how the brain creates consciousness and how people perceive their identities, realities, and meanings in life. Similar to the beauty of complexity captured in Mandelbrot's fractals, great writing often captures the artistic beauty of balance between order and disorder on the edge of chaos; it communicates the ideals, values, and narratives that perceive the coherent contradictions inherent in the human experience. Ideas such as the butterfly effect and self-organization can allow educators to make more meaning out of what may have previously been considered noise, and perhaps sometime in the future it will be possible to develop pedagogies and heuristics for assessing student dynamics and providing the right balance at the edge between creativity and structure to produce effective writing.

Complex systems self-organize, balance at the edge of chaos, and remain diverse and fluid, and workshop classrooms can be profitably understood as doing the same. This

thesis has presented the writing process from perspectives of new theories in science, but more importantly, I hope it gave an accurate portrayal of networked composition courses as teachers and students experience it daily. Complexity theory buttresses the importance of valuing diversity and flexibility, which contribute to greater complexity, creativity, and generative structure. The challenge will be to locate and then maintain that balance.

Readers, writers, and texts are interdependently specified and embedded in particular historical, cultural, and physical networks. These organic systems have dynamic, self-organizing properties that cannot be adequately explained or understood through analysis of individual components or processes. In addition, current interdisciplinary research on complex systems, distributed cognition, and situated cognition can provide us with important new perspectives, methods, and analytical tools for understanding composing situations. What does a theory of composing situations as ecological systems do for composition as a field? How does it improve our understanding of the writing process? I suggest that further research in the connections between writing and complexity offers innovative explanatory insights to a more comprehensive understanding of the writing process.

Cognitive scientists studying complex systems and distributed cognition recognize the difficulties inherent in moving beyond the individual as a unit of analysis. A central problem is how to fix the boundaries of the study if we are to view individuals and their environment as co-originating. One solution is for researchers to select systems bounded in time and space where the traffic and noise is low. Writing situations, however, do not always offer such well-defined boundaries for researchers. It can be difficult to establish where the noise is low. Perhaps this is why the scope of research in

composition initially focused on texts, only gradually broadening out to encompass authors (typically conceived as solitary figures), individual readers, particular writing tasks, and social and historical contexts. In circumscribing an arena of study, we must be much more discriminating in our definition of what is within the system and what is outside of the system. This task is not as difficult as it may appear; but it is nearly impossible to try to construct some standard unit of analysis that will apply in every case. Instead, we must establish, for each study, some bounds that make sense, that open a reasonable space for analysis, and that do not exclude parts of terrain that are significant to our understanding. In this way, we may be able to more closely and rigorously articulate the properties and dynamics of composition.

Particularly within computer assisted instruction, where chaos and complexity are more readily apparent than in traditional class structures, these new understandings might promote greater opportunities for learning, greater opportunities for the production of creative and “orderly” texts, and even greater opportunities for the generation of new and provocative kinds of texts. Still, within CAI we can locate theories and practices of composition which have dominated our field since its origins in the 1960s, namely those subsumed under Berlin’s rubrics regarding our epistemological and ideological orientations. The notion of collaborative writing is associated with complexity theory when considering each writer as an agent in a complex system. In this model, each agent has limited domain knowledge but working together, they can produce texts of increased creativity, depth and breadth of knowledge, and effectiveness addressing the audience than either writer would have likely produced alone. The understanding we gain from

studying composing situations as complex ecological systems should help us as we consider the changes wrought by new technologies.

Furthermore, as new technologies for composing and communication evolve and proliferate, new discourse arenas are emerging, and existing ones are fundamentally and permanently changing. We need to account for not only the social situatedness of composition but its material situatedness as well. A complex ecological approach to composition could illuminate aspects of composing that are of particular interest to a wide range of scholars right now, including the emergence of genre, the development of literacy in diverse situations, the connection between the cognitive and the social in composing, the social construction of disciplinary knowledge, the impact of new technologies on composing situations, and the equitable and authentic assessment of composing. A theory of writing as a complex adaptive system is apropos for resolving some perplexing questions and intransigent problems in composition studies.

Just as there are inequities in access to other social and material resources, there continue to be inequities in both access to new technologies and the ways they are being used. We need to be mindful of how computers, readers, writers, and compositions will shape and be shaped by their ecosystems, while there is still time to influence emerging social and physical structures surrounding their use. How will computer classrooms be arranged? What hardware, software, and network access will be provided, and how often can it be serviced and upgraded? What kinds of support can we provide for multimedia, hypermedia, virtual reality, and other experimental compositions? How will we ensure that access to technological resources—not just hardware and software but human resources we well—will be equitable? What will we want our students to know and know

how to do when they leave our computer-based classes in rhetoric, composition, creative, writing, and literature? Furthermore, the impact of technological changes in our field affords us the opportunity to step back and reconsider more conventional composing environments as well as rethinking our research programs, and to re-conceptualize our goals for educating readers and writers. The real value in taking an ecological perspective is that it compels us to ask better questions about the dynamic relationships among writers, readers, and texts and drives us toward a deeper understanding of composition. As this study has suggested, computer mediated communications are increasing the complexity of the composition classroom through greater opportunities for students and teachers to interact during every phase of the writing process. In order to capitalize on these opportunities, instructors and students must understand how to best utilize their communication resources to optimize their learning and development as writers.

Because the writing combines social, economic, and cultural forces with public policy and technology issues, this thesis has briefly discussed a wide range of topics. Literacy scholars encourage critical evaluations of national literacy and technology agendas because of the potency of the “literacy myth” spreading the widely held belief that Internet access and technology literacy lead automatically, autonomously, and directly to liberation, personal success, or economic prosperity. As many of the studies cited throughout this paper show, lack of Internet access and technological literacy are more likely to be a symptom of income, education, and race than a cause. The debate over the divide primarily focuses on the future of the divide and proposed public policy measures. Regardless of the debate over the digital divide, the overwhelming trend in

digital access shows that people of all demographic groups are making large gains in acquiring access and, to use Singleton's analogy, the digital glass is filling fast.

Comparing the findings of the different sources reveals that computers and technology are becoming more naturalized into everyday life for most Americans. The "s-curve" of computers and Internet access appear to be reaching a plateau in the near future in much the same way as the telephone, radio, television, and automobile, only much faster. In general, students who have grown up with computers appear to accept the technology and use it because they see it as a beneficial tool that will allow them to be successful, at least in an academic setting, if not in life. As costs decrease and the Internet becomes more universally accessible, the general trend in research regarding Internet usage appears to be moving away from issues of access to questions about how people use the Internet, how people access digital information, how demographic groups perceive online information, and how the Internet changes people?

In order to do an adequate in-depth study into the implications of complexity for composition studies, it is vital that specialists from diverse disciplines join efforts to approach the study of complex systems problems. Cooperation and interdependence are necessary for future interdisciplinary research into complex systems. The Santa Fe Institute provides a model for how future research should be done. Complex systems involve so much information, background, and analysis that is necessary for each discipline to work with others in order to effectively approach these questions and gain an adequate understanding of the dynamics of writing. Disciplines rely on various metaphors, perspectives, epistemologies and ways of thinking and approaching information that the synergistic effect is necessary.

The edge of chaos appears to present the potential for greatest change in student writing. Areas prime for future research include pedagogies, epistemologies, and methodologies that investigate how to describe the writing process in terms of complex systems. It may or may not be possible, but there may be strange attractors within the writing process, which could be different epistemologies and various combinations of ethos, logos, and pathos, which allow writers and readers to challenge their assumptions and preconceptions about the world. Challenging a writer's comfort zones opens greater opportunities for growth and change.

The concept of the mental model, which is closely related to that of the problem space, has become widely used in recent years. The general ideas of mental models with respect to human and computer interaction is that, as the user interacts with the computer, he or she receives feedback from the system that allows him/her to develop a representation of how the system is functioning for a given task. The mental model incorporates the expectations of the system's output in response to the actions. A designer can increase the usability of an interface by using metaphors that allow transfer of an appropriate mental model (e.g. desktop metaphor), designing the interface to be consistent with other interfaces with which the user is familiar (e.g. the standard web interface), and conveying the system's functions to the user in a clear and accurate manner. Feedback to the user is perhaps the most effective way to communicate information to the user and can be used to guide the user's mental model about the system.

Imagining the Writing Process in Phase Space

Another potential avenue for future research in terms of complexity theory involves imagining writing processes and writing theories in a phase space where the system of writing at any one instant can be represented in a three-dimensional space where the coordinates are determined by the process's relationship in terms of three variables. Considering Berlin's examination of composition pedagogies, a theory could be visualized in relation to its position along each continuum representing an epistemology, representation of reality, or theories of writing. These three dimensions can also be thought of in terms of a writer's use of logos, ethos, or pathos. Again, considering a writing process in terms of considerations or emphases on the importance of author, reader, and text might provide a useful heuristic for thinking about how we construct meaning and interpretation from a text. Obviously, there are more than three factors involved in the writing process, but considering more than three dimensions becomes difficult to visualize. It also provides theorists with an abstract model to imagine how an individual writer's process or a teacher's pedagogical practices.

Imagine a continuum of theoretical approaches to the writing process, on one side would be order, linearity, and predictability with systems functioning according to Wolfram's Class I and Class II behaviors. In terms of writing theories, I tend to associate the current-traditional paradigm with this side of the scale (due to its hard rules, grammar, structure, repression of creativity, innovation, and personal style). On the other side, chaos, nonlinearity, and unpredictability operate with Class III behaviors, which some theorists such as Donald Murray and Peter Elbow would probably embrace more of the chaos in the writing process because of its focus on embracing uncertainty, freedom, and

tangents in finding the authentic individual voice. Neither extreme is optimally productive nor fully capable of sustaining itself within a network of complex adaptive systems. The most fascinating region for writing is somewhere in between, where Wolfram's Class IV behavior occurs. Here, at the edge of chaos and the boundary of order is where these three students' writing processes thrive. Each writing process, like a fingerprint, is unique, but they also reproduce similar characteristics, like strange attractors in their writing.

The phase space can be constructed by different variables depending on which variables most interest the observer. For example, in this thesis, I focus on the physical environment in which writers compose. When conceived within a phase space, it might be generative to conceive the writing process in terms of circadian rhythms by looking at the writing time, level of alertness, hunger, temperature, lighting, etc. When considering the writing process in terms of contemporary writing process paradigm, it is conceivable to imagine the phase space in terms of planning, drafting, and revising. The most significant feature of thinking of writing in terms of phase space is that a writing process can be represented by a single point in space at any given instant, but observing the writing process as a dynamic system which recursively flows over time, many times pulling towards a basin of attractors in their process.

This phase space is context sensitive. The environment determines the writer's relative position in their process. The process interacts the way it does with the environment because of an existing history and the ways in which the writer has learned to approach various rhetorical situations. This phase space can also be thought of in terms of a writer developing a schema about how to navigate a writing assignment by

considering audience, language, and reality. Of course, it is also possible to imagine each different phase space interacting with surrounding representations of other relevant variables in the writing process. The entire time that we imagine a writer's process over time is the influence of feedback from the environment in terms of peer review, teacher comments, classroom discussions, or even as tangential as family relationships, physical illness, or ideas that writers have been thinking about after watching a television show, reading a book, or talking to a friend. Once conceived in this way, the writing process begins to be modeled in terms of how many theorists have tried to explain it: As a dynamic, nonlinear, recursive process operating in an open system where emerging ideas, creativity and structure interacting with internal and external stimuli from their environment. The point is that there are many ways to conceive the writing process in terms of a complex phase space because there are so many factors involved in the writing process. The challenge for future research becomes distinguishing between those forces that are most beneficial in helping writers to realize their potential.

Where Do We Go from Here?

The richness of the information and connections between the students and the teacher, should in theory, improve the adaptability of the student writing process. In order for this to happen, entire educational system and community must value and invest time, energy, and resources into the education of students from support, encouragement at home to availability of resources at home, school, and the community, etc. Students need to see why what they are learning is important to their lives, the applicability of the course later on in life beyond pure academic curiosity – while ideal, realistically many

students work for extrinsic reasons because those appear to be what matters and is relevant in their material world. I suggest further research into constructing communities invested in their children's lives and interests to cultivate minds striving for inherent values and ideals instead extrinsic immediate rewards. I also suggest further research into pedagogical methods for teaching students to view their world at more than one level, to see the complexity of life and their writing at many different levels. Many times, the composition of quality texts begins long before fingers touch the keyboard, but in the imagination and creation of chaos and intelligence that emerges from millions of firing synapses and an individuals' authentic voice and experience creating meaningful texts. In addition, the willingness on the part of the student to adapt to different audiences, expectations, requirements, and attempt to seek out the parameters of the writing environment will most likely improve the student's success in any course. Students' abilities to write successfully appear to depend on their ability to navigate the edge of chaos in their lives effectively. Additional research might find interesting connections between the sensitive dependence on the initial conditions of quality and quantity of access to an individual student's academic success.

The far-reaching implications of complexity theory in composition studies could eventually influence how teachers evaluate a student's writing process by considering the nonlinear nature of writing. Conceiving writing as an emergent complex self-organizing system with attractors, bifurcations, and feedback loops could inform some process-oriented pedagogical practices. Complexity theory and chaos are often compared to computer networks, and as Sherry Turkle suggests, the trend towards universal computing, hypertextual writing environments, MUDs, and virtual reality will continue to

change how we conceive reality, identity, and meaning in a text. If complexity theory becomes a generative language and set of metaphors through which to understand writing, it may also provide additional implications for WAC and community service-learning opportunities. These speculations may be grandiose, but in terms of chaos and complexity, they are not that radical because small disturbances can generate large effects. I find these thoughts exciting to contemplate when considering the hope that complexity offers to composition.

While chaos and complexity theory do not provide a panacea for all ills in the field of composition, characteristics describing these systems pervade the writing process. Although there have been multiple attempts to bridge the divide between the arts and the sciences, complexity theory offers many possibilities for scholars from many different disciplines to talk with a common language with concepts, phenomena, and metaphors that they can all associate within their particular field of study. Perhaps, this study is simply another iteration of the strange attractor bridging the arts and sciences and perhaps this small contribution along with Kyburz's recent article will be the small spark that ignites a revolution in composition studies, but if the information interaction within the field is not dynamic, then these contributions may remain dormant for years to come. There is an art to doing science as well as a science for creating art; it is the area in between, the middle ground, peering over the edge where we experience life in the beauty of complexity.

Appendix A

Student Syllabus

COCC301B, Spring, 2004 - Writing in the Sciences

Week 1 (Jan. 20-22)

Tuesday: Introduction to the course—our focus, the kinds of writing tasks (portfolios, daily writing, individual and group forum postings), policies.

Readings due Thursday: Five pieces on the mad cow disease from different publications. As you read, think about why the writer emphasized certain aspects of the topic or used certain techniques for the target audience. Bring some specific comments about the techniques writers used for our discussion Thursday.

- From Bad to Worse
- Border Row
- Gloom Descends
- Profile
- Pro/Con

Thursday: Audiences for science writing; how and where does the personal perspective fit?

Due Tuesday: Start browsing through publications and websites about science for non-scientific readers. You'll be creating your own anthology of readings for the first half of the semester, so think about ways to capture the range of audiences/purposes in your selections.

Week 2 (Jan. 27-29)

Tuesday:

The anthology and analysis assignment

Publication analysis

Readings due Thursday: "The Reader" and "The Writer," both posted on the calendar. Start working on your anthology and analysis.

Thursday: Rhetorical analysis: focus on reader or audiences. Audiences for science writing and kinds of evidence effective with those audiences.

Due Tuesday: Post your analysis before class begins on Tuesday.

Re-read the common articles assigned in Week 1 with special attention to paragraphing, sentence structure and length, and word choices.

Read three student samples--"Analyze This," "Analyzing the Audience of *Scientific American*," and "Analysis of International Wildlife," posted on the calendar.

Week 3 (Feb. 3-5)

Tuesday: Peer review of draft anthology analysis

Due Thursday: Anthology and analysis.

Thursday: Connecting analysis of reader with topic/text analysis.

Post group DAILY writing on the Forum.

Due Tuesday: Read three student samples - “The power of writing tools,” “Science writing for stakeholder audiences,” and “The use of visuals in the writing process.”

Week 4 (Feb. 10-12)

Tuesday: Audience/text/context revisited.

Select an article from your anthology to work on for in-depth analysis.

Due Thursday: Read “Context analysis” and two student samples - “Grab’n’Go News about Science” and “Write with Personality.”

Thursday: Select another article from your anthology for another round of in-depth analysis

Post DAILY writing on the Forum. Be sure to read other students' Forum postings.

Moving from the Forum posting into a preliminary draft

Review student samples and draft two to four pages analyzing the text of one assigned reading.

Submit draft via e mail by Monday at noon.

Week 5 (Feb. 17-19)

Tuesday: Visual paragraphing.

More detailed analysis of one article you worked on last week.

Post DAILY writing on the Forum.

Thursday: Moving into portfolio 1: reconsidering potential audiences and goals for your drafts.

Read student samples: “Writing Techniques for a Successful Article,” “Keeping Students Interested in the Classroom,” “Personalization in Science Writing,” “Scientifically Civilized,” “Science Writing to Draw in Readers,” and “Frog Guts and Science Writing.”

For Tuesday: Draft and revise. Prepare first draft for peer review.

Week 6 (Feb. 24-26)

Tuesday: Peer review—how and why to workshop. First workshop on draft for portfolio 1 (required work on a peer draft). Continue drafting for portfolio 1. Don’t forget that I’ll comment on drafts-in-progress until one week before the portfolio is due.

For Thursday: Continue drafting and revising portfolio 1.

Thursday: Work day. A great day for a conference! Continue drafting to complete required pages for portfolio 1.

For Tuesday: Prepare another draft and revise first draft for workshop.

Week 7 (March 2-4)

Tuesday: Workshop on draft for portfolio 1 (required work on a peer draft). Today is the last day to submit drafts for my review before the portfolio comes in.

For Thursday: Continue drafting and revising portfolio 1.

Thursday: Polishing drafts! Final workshop on draft for portfolio 1 (required work on a peer draft).

Read “One Approach to Cutting Wordiness” and “Editing and Proofreading Strategies.” See also, the Online Writing Center module called Editing and Proofreading Strategies for more explanation; <http://writing.colostate.edu/references/processes/editing/index.html>

For Tuesday: Prepare portfolio 1.

Week 8 (Mar. 9-11)

Tuesday: Portfolio 1 with postscript due.

Thursday: Possible topics for portfolio 2

Read three student samples - “Pointing the Finger,” “AIDS in Africa,” and “Minimizing the Threat of Catastrophic Fire.”

Be sure to check out the Online Writing Center resources on doing research. Go to <http://writing.colostate.edu>. Click on Resources for Writers and Teachers. Then click on Interactive Demonstrations if you would like to review how to do research on the Web. Or click on Library Links and Guides if you need help understanding how to do library searching.

Week 9 (Mar. 23-25)

Tuesday: Doing research. What tips do you have to share, especially pointers you’ve learned the hard way? Best resources? How to keep track of sources? Who might be candidates for interviews or surveys? What other kinds of research, besides library/Internet browsing, can count for the portfolio?

Read four student samples - “The Language of Behavior,” “Unit 5: Mammals,” “Advocate for Retired Chimpanzees,” and “Solving the Poop Problem.”

For Thursday: Browse sources and start focusing on your topic for portfolio 2.

Thursday: Informing

Send your DAILY via e mail.

Read “A Handy-Dandy Explanation of One Way to Avoid Misusing the Lowly Comma”

For Tuesday: Spend at least an hour thinking about potential topics, especially which one seems most “do-able” for portfolio 2. Look for more source material or line up interviews. You’ll commit to a topic on Tuesday, so be sure to spend enough time this weekend to see if you can find all the resources you need for at least 15 pages of finished work. Do you love this topic? If not, now’s the time to change your mind, not next week!

Week 10 (Mar. 30-Apr. 1)

Tuesday: Commit to a topic (see the DAILY for today). **Remember, how well your writing communicates to its target audience for its stated purpose is the key criterion for portfolio 2.**

Read student samples - “Cry Wolf,” “They Who Dance with Wolves,” and “Can We Cry and Dance with Wolves at the Same Time.”

Thursday: Detailed audience analysis for one piece planned for portfolio 2.

For Tuesday: Read, read, read. Then think and begin drafting.

Week 11 (Apr. 6-8)

Tuesday: Arguing, 1.

Read “Arguments” on the Online Writing Center, sections labeled Overview, Definition, and Parts of an Argument.

For Thursday: Read, read, read. Then think and continue drafting.

Thursday: Arguing, 2.

Read remaining sections of “Arguments” on the Online Writing Center.

Read “Detailed Criteria for Arguments in Portfolio 2” and “Mediating/Negotiating Arguments.”

For Tuesday: Draft!

Week 12 (Apr. 13-15)

Tuesday:

Detailed audience analysis for second piece planned for portfolio 2.

For Thursday: Continue drafting.

Thursday: First workshop on draft for portfolio 2 (required work on a peer draft)

Send e mail with your revision plan. (See prompts under DAILY writing.)

For Tuesday: Keep drafting on your second piece for portfolio 2.

Week 13 (Apr. 20-22)

Tuesday: Work day (a great opportunity for a conference)

For Thursday: Continue drafting.

Thursday: Second workshop on draft for portfolio 2 (required work on a peer draft)

Send e mail with your revision plan. (See prompts in DAILY for today.)

Week 14 (Apr. 27-29)

Tuesday: Workshop on draft for portfolio 2 (required work on a peer draft)

Send e mail with your revision plan today.

For Thursday: Revise.

Thursday: Style and editing workshop on draft for portfolio 2 (required work on a peer draft)

For Tuesday: Revise!!! Polish pieces for submission.

Week 15 (May 4-6)

Tuesday: Portfolio 2 due. Complete postscript to submit with portfolio. (See prompts in DAILY writing for today.)

Thursday:

Forum writing/reflection day: What were the major factors shaping your writing on portfolio 2? Did the larger cultural expectations about science writing have any effect on your writing? How did conventions for your science discipline affect your writing for portfolio 2?

How does your writing shape your readers' view of science generally and of your science discipline specifically?

How can you apply what you've learned and practiced this term to be successful in writing in your field?

Finals Week

Student evaluations. Portfolios returned.

Appendix B - Portfolio Assignment Descriptions (posted on the *Writing Studio* Class Calendar)

Portfolio 1

The first portfolio, due on March 9, should include your best writing from the first part of the semester. Specific requirements:

- Include at least 12 pages of finished, polished writing in three or four pieces.
- One piece must be at least five pages.
- One piece may be the revised anthology analysis

Please remember to clip all the drafts of these pieces to the final versions, with the final draft on top of the stack. All final drafts must be typed in a readable font (12 point Times New Roman works well), double-spaced, with 1 inch margins.

Please specify your target audience and your goal for the piece at the top of the final draft. In other words, the final essays for the portfolio are not academic exercises written to a composition teacher to prove that you have read a selected text. Rather, as we'll discuss in class, you'll determine readers who need to know or care about knowing what you have to say about contemporary science writing. Essays in portfolio 1 are typically informative or argumentative, but you can also write for some other clearly stated goal. Make sure you keep your goal for the essay, as well as the reader you're writing for, in mind throughout your drafting and revising.

Criteria for the Portfolio

Audience: You specify the audience. You might write to classmates (or one particular classmate), high-school science teachers, or students in future sections of COCC301B. You may write to professors in your field only as teachers of reading/writing/critical thinking skills, not as experts in the discipline. Do not assume that your readers have read the piece(s) or journal you're analyzing. Be sure to include specific examples from the text(s) to build your readers' understanding of the text(s) in question.

Purpose: You specify the purpose appropriate to your audience. One element of final evaluation will be how well you fulfill your purpose for the specified readers.

Focus: Help your readers appropriately by announcing what you'll cover in the paper. A narrowly focused, clearly stated claim is both easier for readers to grasp and easier for you to develop or support. Even if you're writing a reflective paper, you need to orient the reader to your overall point with some kind of focusing or forecasting statement.

Development: Support your claim(s) with specific examples from the text(s) including quotes, paraphrases and summaries, as appropriate. Include, as appropriate for your paper, specific examples of how evidence, organization, style, tone, etc., lead you to the conclusions you draw. Unsupported assertion isn't an acceptable approach in these papers. Moreover, details stick in readers' mind and support your overall point more effectively than do general statements. Check each point in your paper and make sure you

back it up with adequate support. Your support will include textual evidence, but you need to show your thinking as well. So plan to include your own analytic thinking and personal experience where appropriate. Refer to the texts with author and title "tags" rather than formal footnotes or parenthetical citations. If you use other sources, please see me about how to integrate source material into your sentences and how to prepare a Works Cited page for me.

Organization: Arrange your paper in a coherent, readable, logical manner. Avoid merely providing summaries of each text or listing techniques. Show *how* and *why* the writer made his/her choices or *how* and *why* you draw the conclusions you do.

Style: Write in a style that is clear and readable with few, if any, grammatical, mechanical or usage errors. Make stylistic choices appropriate for your audience or the target publication.

Layout: Although visuals and headings are not required for this portfolio, you may find that they help you. Headings can often signal the organization of your paper, particularly helpful for readers if your claim is complex or your paper exceeds eight pages. Visuals—graphs, tables, charts, pictures—can all enhance the appeal of your papers, so use them if they're appropriate given your audience and purpose.

You don't need a separate title page. Be sure to leave one inch margins all around but, otherwise, don't waste paper.

Portfolio 2

The second portfolio, due May 4, includes your work on an individual topic this term. It will count for 50% of the final grade. You must include two polished papers on an approved topic, totaling approximately 15-18 pages. The audience and purpose of each paper should be noted at the top of each final draft.

You will also need to include photocopies of all articles you cite or refer to in your final drafts, as well as required workshop sheets for the portfolio.

Please remember to clip all the drafts of these papers to the final versions, with the final draft on top of the stack. All final drafts must be typed in a readable font (12 point Times New Roman works well), double-spaced, with 1 inch margins.

Criteria for the Portfolio

Topic: Your topics must be related to science in some way, and topics must be researched. If you aren't sure your topic will work, check with me.

Audience: You specify the audience. Sometimes it's easiest to think in terms of possible publications to detail the intended audience. The only audiences you *cannot* write to in this portfolio are advanced students and experts in your field.

Purpose: You specify the purpose appropriate to your audience. The major element of final evaluation will be how well you fulfill your purpose for the specified readers. The only limitations on purpose are

1. you must work with source material, and
2. creative non-fiction is not an option.

Focus: Help your reader appropriately by announcing what you'll cover in the paper. A narrowly focused, clearly stated claim or thesis is both easier for readers to grasp and easier for you to develop or support. Even if you're writing a reflective paper, you need to orient the reader to your overall point with some kind of focusing or forecasting statement.

Development: Support your claim(s) with specific detail from sources appropriate for your audience and purpose. Unsupported assertion isn't an acceptable approach in these papers. Moreover, details stick in readers' mind and make your point more effectively than do general statements. Check each point in your paper and make sure you back it up with adequate support. You may include your own analytic thinking and personal experience where appropriate.

Organization: Arrange your paper in a coherent, readable, logical manner. Avoid merely providing summaries of sources or a patchwork of material taken from various sources.

Sources and Documentation: Don't ignore experts at CSU or contacts through the CSU/county extension service. We have experts on campus who will be happy to talk to you about specific topics and issues.

We'll talk in class about ways to integrate source material and information about sources into your papers. In general, plan to incorporate citation information into your sentences. (We'll go over this in detail in class.) No footnotes. You must clearly quote even paraphrased material and identify sources whenever you use them, including interviews and any informal survey data. Each paper in portfolio 2 must have a Works Cited list giving complete bibliographic information about the sources noted in the paper, including all Internet sources.

Style: Write in a style that is clear and readable with few, if any, grammatical, mechanical or usage errors. Make stylistic choices appropriate for your audience or the target publication.

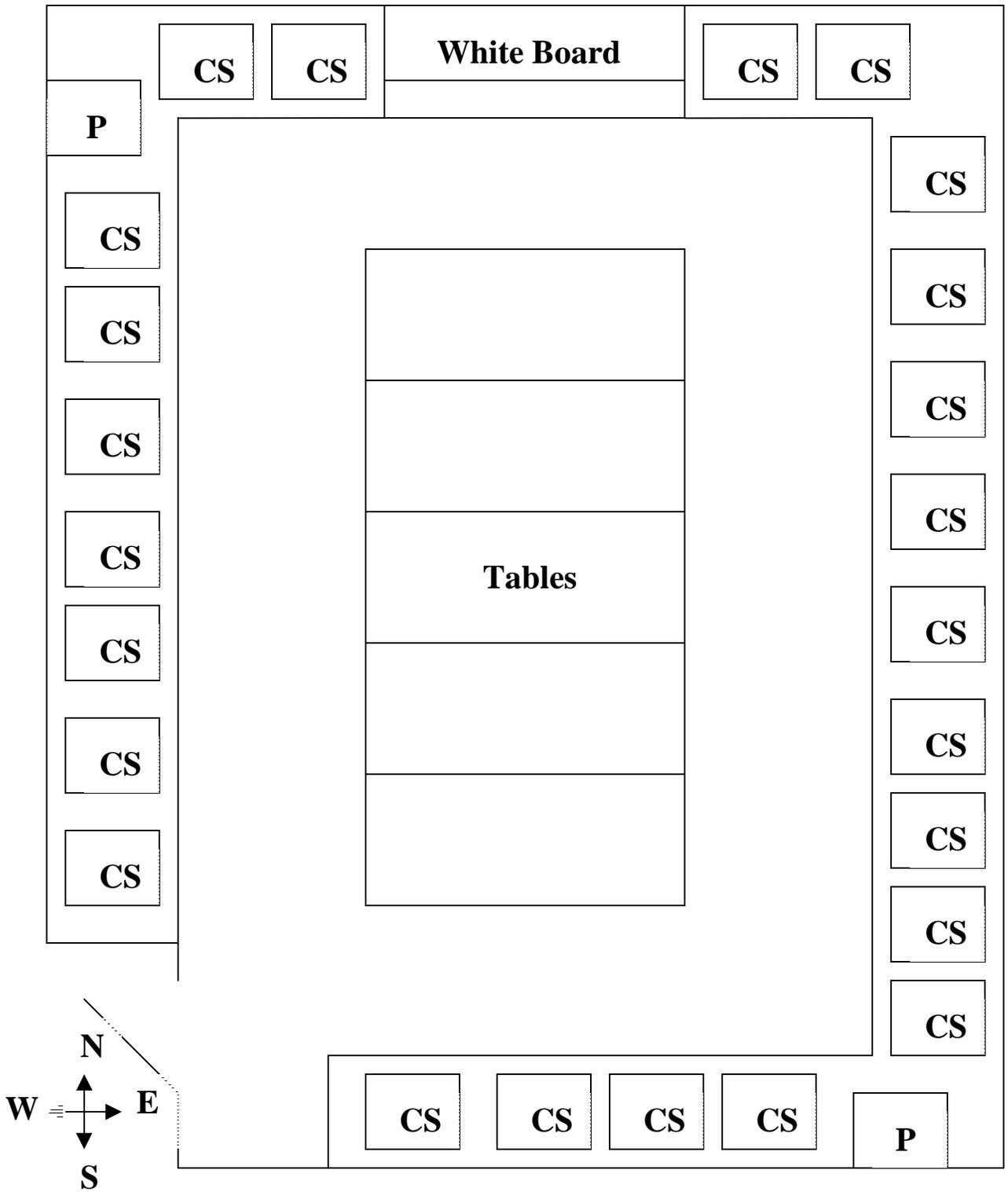
Layout: Although visuals and headings are not required for this portfolio, you may find that they help you. Headings often signal the organization of your paper, particularly helpful for readers if your claim is complex or your paper exceeds eight pages. Visuals—

graphs, tables, charts, pictures—can all enhance the appeal of your papers, so use them if they're appropriate given your audience, purpose, and target publication.

You don't need a separate title page. Begin your Works Cited (with this heading) list two or three spaces after your text ends. Be sure to leave one inch margins all around but, otherwise, don't waste paper. If you use a multiple-column format, don't leave excessive space between columns and reduce the outside margin slightly. See me for specifics.

P = Printer **CS= Computer station**

Appendix C - Classroom Layout



Appendix D - Initial Survey

Age: _____

Major: _____

Gender: _____

Ethnicity: _____

Please circle the number that best describes your response to the following statements.

A **number 1** means that you “**strongly disagree**” with the statement.

A **number 3** indicates that you are neutral to the statement. If you are neutral, please explain why.

A **number 5** indicates that you “**strongly agree**” with the statement.

1. I enjoy writing and I find it fulfilling to express my ideas and opinions through my writing.

1 2 3 4 5

2. I enjoy writing frequently for reasons other than school or work (e.g. personal journal, personal enjoyment, express emotions, think out my opinions, write letters/e-mail to friends and family, etc.).

1 2 3 4 5

3. I interested in learning about writing strategies, influences, and/or theories that I can use to improve my writing.

1 2 3 4 5

4. I write at the same computer or desk every time I write.

1 2 3 4 5

5. I write at the same time of day every time I write.

1 2 3 4 5

6. I wait until the last minute to finish my writing for school.

1 2 3 4 5

7. I usually have someone I trust look over my paper to help me revise my writing before I turn it in.

1 2 3 4 5

8. I consider myself a good writer.

1 2 3 4 5

9. I feel comfortable, competent, and effective when I write on a computer.

1 2 3 4 5

10. I prefer to use paper and pen or pencil to write down my ideas before I type my writing.

1 2 3 4 5

11. I use a wide variety of writing tools and resources when I write.

1 2 3 4 5

Please circle the number that best reflects your attitudes about writing.

Good writers are born, not made 1 2 3 4 5

I avoid writing	1	2	3	4	5
People have said, "Writing can be learned, but it can't be taught."	1	2	3	4	5
Do you believe it can be learned?	1	2	3	4	5
Do you believe writing can be taught?	1	2	3	4	5
Practice is the most important part of being a good writer.	1	2	3	4	5
I am able to express myself clearly in my writing.	1	2	3	4	5
Writing is a lot of fun.	1	2	3	4	5
Good teachers can help me become a better writer.	1	2	3	4	5
Talent is the most important part of being a good writer.	1	2	3	4	5
Anyone with average intelligence can learn to be a good writer.	1	2	3	4	5
I am no good at writing.	1	2	3	4	5
I enjoy writing.	1	2	3	4	5
Discussing my writing with others is an enjoyable experience.	1	2	3	4	5
Compared to other students, I am a good writer.	1	2	3	4	5
Teachers who have read my writing think	1	2	3	4	5
I am a good writer.					
Other students who have read my writing think I am a good writer.	1	2	3	4	5
My writing is easy to understand.	1	2	3	4	5

Please circle the number that best reflects your attitudes about computers.

The challenge of learning about computers is exciting.	1	2	3	4	5
I am confident that I can learn computer skills.	1	2	3	4	5
Any patient and motivated person can learn to use a computer.	1	2	3	4	5
Learning to operate computers is like learning any new skill— the more you practice, the better you become.	1	2	3	4	5
I feel apprehensive about working with computers.	1	2	3	4	5
I have difficulty understanding the technical aspects of computers.	1	2	3	4	5
It scares me to think that I could cause the computer to destroy a large amount of information by hitting the wrong key.	1	2	3	4	5
You have to be a genius to understand all the special commands used by most computer programs.	1	2	3	4	5
Given the opportunity, I would like to learn about and use computers.	1	2	3	4	5
I avoid computers because they are unfamiliar and intimidating.	1	2	3	4	5
Computers are necessary tools in both educational and work settings.	1	2	3	4	5

Appendix E - Second Class Survey (Week 9)

Complexity of the Writing Environment Survey

Age: _____ Major: _____
Gender: _____ Minor: _____
Ethnicity: _____ Primary Language: _____

1. What is your parent's average annual household income?

___ Less than \$20,000	___ \$65,000 – \$80,000	___ \$125,000 – \$140,000
___ \$20,000 – \$35,000	___ \$80,000 – \$95,000	___ \$140,000 – \$155,000
___ \$35,000 – \$50,000	___ \$95,000 – \$110,000	___ \$155,000 – \$170,000
___ \$50,000 – \$65,000	___ \$110,000 – \$125,000	___ \$170,000 or more

2. What is your current annual household income?

___ Less than \$10,000	___ \$25,000 – \$30,000	___ \$45,000 – \$50,000
___ \$10,000 – \$15,000	___ \$30,000 – \$35,000	___ \$50,000 – \$60,000
___ \$15,000 – \$20,000	___ \$35,000 – \$40,000	___ \$60,000 – \$65,000
___ \$20,000 – \$25,000	___ \$40,000 – \$45,000	___ \$65,000 or more

3. How would you describe your current living position? ___ Rent ___ Dormitory
___ Own

4. How many people live with you, including yourself? _____

5. What year did you first experience regular access? _____

For questions 6-8, please fill in the corresponding number from the list below:

1-Home 2-School 3-Parent's Work 4-Friend's House 5-Relative's
Home

6-Business/Store 7-Church 8-Work 9-Other (please describe):

6. Where did you first experience your regular access (3 times a week or more) to computers?__

7. Where do you currently access the Internet? _____

8. Where do you currently access the Internet most often? _____

9. What is the connection speed at this location?

DSL	Cable Modem	Ethernet	Wireless	ISDN
Satellite	T1/T3	56Kbps Dial-up	24Kbps Dial-up	
Don't know	Other: _____			

10. What Internet Service Provider do you typically use? (e.g. Comcast, AOL, Earthlink, NetZero, CSU, etc.) _____

11. Which Internet Browser do you use most often? (e.g. Internet Explorer, Netscape, Mozilla, Opera, etc.) _____

12. How many hours a week do you usually use the Internet? _____.

13. How many computers do you own? _____ When was the computer purchased? _____

Circle all of the technological devices or online services you currently own or use. Next to each item place the corresponding number of the person who originally purchased this device or service:

1 -Myself 2 -Parents 3 -Friend 4 -Relative 5 -Spouse 6-Other: _____

Cell phone DVD Player CD-ROM CD Burner Printer
 MP3 Player Scanner HDTV Satellite TV Cable TV
 Home Stereo Desktop Computer Laptop Computer CD Player
 Webcam Digital Camera Digital Camcorder Plasma TV
 DVD Recorder Satellite Radio Fax machine PDA/Palm Pilot
 Wireless Connection/Network External hard drive Computer Speakers
 Video Game Consol (Playstation, XBox, etc.) Video recording system
(i.e.TIVO) Other (please describe):

Please circle all of the activities do you regularly participate in while **online**. Next to the items you circle, please indicate the typical number of hours you spend per week participating in this activity on the line the left to the activity.

E-mail Writing Blogging Webcam
 Instant Messenger/chat Trade Stocks Online Surveys
 Online Banking Weather Current Events/ News Gambling
 Record streaming video Watch Streaming video Selling
 Downloading images Discussion Forums Make Travel plans
 Computer games Listening to Music Downloading music
 Researching on the Internet Surfing the Internet Shopping
 Fantasy Sports (i.e. Fantasy Baseball) MUDs, MOOs, MUSHes, etc.

Other (please describe):

What are the main reasons why you use the Internet?

What are the reasons why you do not use the Internet?

Please circle the number that best reflects your attitudes about writing.

Good writers are born, not made	1	2	3	4	5
I avoid writing	1	2	3	4	5
People have said, "Writing can be learned, but it can't be taught."	1	2	3	4	5
Do you believe it can be learned?	1	2	3	4	5
Do you believe writing can be taught?	1	2	3	4	5
Practice is the most important part of being a good writer.	1	2	3	4	5
I am able to express myself clearly in my writing.	1	2	3	4	5
Writing is a lot of fun.	1	2	3	4	5
Good teachers can help me become a better writer.	1	2	3	4	5
Talent is the most important part of being a good writer.	1	2	3	4	5
Anyone with average intelligence can learn to be a good writer.	1	2	3	4	5
I am no good at writing.	1	2	3	4	5
I enjoy writing.	1	2	3	4	5
Discussing my writing with others is an enjoyable experience.	1	2	3	4	5
Compared to other students, I am a good writer.	1	2	3	4	5

Teachers who have read my writing think I am a good writer.	1	2	3	4	5
Other students who have read my writing think I am a good writer.	1	2	3	4	5
My writing is easy to understand.	1	2	3	4	5

Please circle the number that best reflects your attitudes about computers.

The challenge of learning about computers is exciting.	1	2	3	4	5
I am confident that I can learn computer skills.	1	2	3	4	5
Any patient and motivated person can learn to use a computer.	1	2	3	4	5
Learning to operate computers is like learning any new skill— the more you practice, the better you become.	1	2	3	4	5
I feel apprehensive about working with computers.	1	2	3	4	5
I have difficulty understanding the technical aspects of computers.	1	2	3	4	5
It scares me to think that I could cause the computer to destroy a large amount of information by hitting the wrong key.	1	2	3	4	5
You have to be a genius to understand all the special commands used by most computer programs.	1	2	3	4	5
Given the opportunity, I would like to learn about and use computers.	1	2	3	4	5
I avoid computers because they are unfamiliar and intimidating.	1	2	3	4	5
Computers are necessary tools in both educational and work settings.	1	2	3	4	5

Appendix F – Final Complexity of the Writing Environment Survey

Age: _____

Major(s): _____

Gender: _____
Ethnicity: _____

Minor(s): _____
Primary Language:

1. Please circle the highest level of education your parents achieved?

Father : High School Associate's Degree Bachelor's Degree Master's Degree
First-Professional Degree Ph. D. Other: _____ Don't Know

Mother: High School Associate's Degree Bachelor's Degree Master's Degree
First-Professional Degree Ph. D. Other: _____ Don't Know

2. What is the highest level of education you hope to achieve?

Bachelor's Degree Master's Degree First-Professional Degree
Ph. D.
Other: _____ Don't Know

3. How many credit hours are you taking this semester? _____

4. Outside of class-related work, how many hours per week do you typically work?

5. How many times have you been absent for this class? _____

6. What are some of the reasons have you missed class?

7. How many hours of sleep do you typically get during the school week? ____
Weekends? ____

8. How many hours have you spent researching information for portfolio 2? _____

9. How many hours have you spent writing/drafting portfolio 2? _____

10. How many hours have you spent editing/ revising portfolio 2? _____

11. How long have you typically written at any one time while working on this portfolio?

12. Typically, what time of day do you write?

- A** Early morning (3 a.m. – 8 a.m.) **B** Morning (8 a.m. – 12 p.m.)
C Afternoon (12 p.m. – 5 p.m.) **D** Evening (5 p.m. – 10 p.m.)
E Late night (10 p.m. – 3 a.m.) **F** Inconsistent times

13. How many times this semester have you communicated with classmates outside of class time to discuss your writing? _____

14. How many times this semester have you communicated with Kate Kiefer outside of class to discuss your writing? _____

15. How do you prefer to communicate with classmates?

- Face to face E-mail Telephone
Other:_____

16. How do you prefer to communicate with your instructor?

- Face to face E-mail Telephone
Other:_____

17. Do you have a learning disability? **Yes** **No**

If so, please describe:_____

18. Do you feel that you have any other handicap that puts you at a disadvantage when you write? **Yes** **No**

If so, please describe:_____

Please circle the number that best describes how often you participate in the following activities:

1 = Never 2 = Rarely 3 = Occasionally 4 = Often 5 = Very Often

I use a computer or word processor to prepare reports or papers

1 2 3 4 5

I use e-mail to communicate with an instructor about coursework

1 2 3 4 5

I use e-mail to communicate with classmates about coursework

1 2 3 4 5

I use a computer tutorial to learn material for a course or developmental program

1 2 3 4 5

I participate in class discussions using an electronic medium (i.e.: listserv, WebCT, online discussion forum, chat room, etc.)

1 2 3 4 5

I search the Internet for information related to a course

1 2 3 4 5

I use a computer to retrieve materials from a database or online journals

1 2 3 4 5

I use a computer to retrieve materials from a library not at this institution

1 2 3 4 5

1 = Never 2 = Rarely 3 = Occasionally 4 = Often 5 = Very Often

I use a computer to produce visual displays of information (charts, graphs, spreadsheets)

1 2 3 4 5

I use a computer to analyze data (statistics, forecasting)

1 2 3 4 5

I have developed a web page

1 2 3 4 5

I have developed a multimedia presentation (i.e. PowerPoint, Macromedia Flash)

1 2 3 4 5

I consume caffeine while writing

1 2 3 4 5

I eat while writing

1 2 3 4 5

I talk with another person while writing:

In person 1 2 3 4 5

By telephone 1 2 3 4 5

E-mail 1 2 3 4 5

Instant messenger/online chat 1 2 3 4 5

I switch between different windows, applications, and programs while I write

1 2 3 4 5

I listen to music while writing

1 2 3 4 5

I take a break from writing during a writing session to stretch, get up to walk around, eat, etc.?

1 2 3 4 5

Please describe how you feel that your writing process has changed over the course of the semester.

Please circle the number that best reflects your attitudes about writing.

Good writers are born, not made	1	2	3	4	5
I avoid writing	1	2	3	4	5
People have said, "Writing can be learned, but it can't be taught."	1	2	3	4	5
Do you believe it can be learned?	1	2	3	4	5
Do you believe writing can be taught?	1	2	3	4	5
Practice is the most important part of being a good writer.	1	2	3	4	5
I am able to express myself clearly in my writing.	1	2	3	4	5
Writing is a lot of fun.	1	2	3	4	5
Good teachers can help me become a better writer.	1	2	3	4	5
Talent is the most important part of being a good writer.	1	2	3	4	5
Anyone with average intelligence can learn to be a good writer.	1	2	3	4	5

I am no good at writing.	1	2	3	4	5
I enjoy writing.	1	2	3	4	5
Discussing my writing with others is an enjoyable experience.	1	2	3	4	5
Compared to other students, I am a good writer.	1	2	3	4	5
Teachers who have read my writing think	1	2	3	4	5
I am a good writer.					
Other students who have read my writing think I am a good writer.	1	2	3	4	5
My writing is easy to understand.	1	2	3	4	5

Please circle the number that best reflects your attitudes about computers.

The challenge of learning about computers is exciting.	1	2	3	4	5
I am confident that I can learn computer skills.	1	2	3	4	5
Any patient and motivated person can learn to use a computer.	1	2	3	4	5
Learning to operate computers is like learning any new skill— the more you practice, the better you become.	1	2	3	4	5
I feel apprehensive about working with computers.	1	2	3	4	5
I have difficulty understanding the technical aspects of computers.	1	2	3	4	5
It scares me to think that I could cause the computer to destroy a large amount of information by hitting the wrong key.	1	2	3	4	5
You have to be a genius to understand all the special commands used by most computer programs.	1	2	3	4	5

Given the opportunity, I would like to learn about and use computers.	1	2	3	4	5
I avoid computers because they are unfamiliar and intimidating.	1	2	3	4	5
Computers are necessary tools in both educational and work settings.	1	2	3	4	5

Appendix G - First Student Interview Questions

1. What do you like about writing? What do you struggle the most with when you write?

2. Do you write for any reason besides schoolwork?
3. How do you approach your school writing assignments?
4. How do you feel about your most recent portfolio assignment for CO 301?
5. How long have you been working on this paper?
6. How do you feel about your portfolio? What are the strengths and weaknesses of your first portfolio for this class?
7. How did the articles and readings in class influence your portfolio writing?
8. How did you define your audience? How did you decide your words and voice for the portfolio?
9. Describe any other voices or influences from other classes, conversations, workshops, TV shows, readings, etc. that crossed your mind as you were thinking about and writing your portfolio? Do you ever ask yourself questions about your own writing? What kinds of questions do you ask? Do you ever read your writing aloud? Why or why not?
10. Have you ever been to the writing center for help on a paper or used any of the online writing texts? If so, what did you think? Do you know anyone who has used the writing center and what their experience was like? Have you ever asked a teacher, peer, friend, parent, etc. for help on your paper through e-mail or any other electronic medium?
11. Describe the environment you typically write in. Where have you worked on this paper? When and where do you usually write for school assignments? Do you write in a different place, time, environment depending on what type of writing you are doing? Why?
12. What resources (programs, reference materials, people, online texts, books, anything you use outside of your own head) do you typically use while you brainstorm, write, and revise?
13. In your typical writing environment, are there any distractions that disturb your thoughts, such as voices, traffic, animals, etc? Are you distracted by anything?
14. What other activities, if any, do you do while writing (e.g. eat, drink, listen to music, talk on the phone)? Do you ever multi-task when you write? How? Why? Do any of these outside influences distract or empower your writing or do you tend to ignore them? Describe the perfect writing environment.

15. Is this the usual time of day for you to work on your writing?
16. What other things have you done today?
17. What do you plan on doing later today?
18. Did any of these activities cross your mind as you were writing?
19. How do you feel physically?
20. Is the temperature comfortable where you typically write?
21. What stress do you feel right now?
22. When was the last time you ate? What did you have?
23. Do you feel that there is adequate lighting where you typically write?
24. I noticed from your response to the initial survey that you said....Why?
25. What other ideas go through your head as you write that are not directly related to what you are writing?
26. Describe any habits that you have developed in college related to your writing process?
27. Do you know why you have picked up those habits?
28. Do you usually have someone read your paper before you turn it in? If so, who do you have read your paper? Why? What do you ask them to focus on? If not, who would you ask to read your paper and what areas would you ask them to concentrate on?
29. Do you have home access to a computer, Internet, and resources that you feel are helpful with your writing? Please describe how this affects your writing. If you have these at home, how does it affect what you think about writing at school, in class, or in a computer lab? If you do not, do you feel that not having these resources puts you at a disadvantage compared to other students with home access?
30. What do you like best about writing on computers? What do you like the least?
31. In what ways do you find computers to be helpful and empowering when you write? In what ways do you find them to be restrictive or limiting as you write?
32. Do you have any questions for me?

Appendix H – Second Interview Questions

1. What is your topic?

2. Why did you choose your topic?
3. How did you decide on your topic?
4. Who is your audience?
5. What kinds of questions did you ask yourself about your audience?
6. What point of view are you using? Why?
7. What is the purpose of your article?
8. What goals do you have for this portfolio/ article?
9. How do you want to influence your audience?
10. What visual elements have you considered using?
11. What decisions did you make with word choices for your audience?
12. How do you employ logical argument in your article?
13. How do you appeal to your audience's emotions in your article?
14. How do you establish your authority or credibility in your article?
15. How do you feel about what you wrote for this session?
16. What was your plan for this writing session?
17. What were you thinking about as you wrote?
18. Where are you in your writing process?
19. How much time have you spent working on it so far?
20. Where have you worked on your paper?
21. How did you brainstorm your paper?
22. How do you feel physically?
23. Do you have any questions for me?

Appendix I – Third Student Interview Questions

1. Where are you in your writing process?

2. What did you work on today? What did you have done before this writing session and what did you accomplish?
3. What was your plan for this writing session? What goals or plans did you have before you came in today, as far as what you wanted accomplished?
4. How do you feel about what you wrote for this session?
5. What were you thinking about as you wrote?
6. How much time have you spent working on it so far?
7. Where have you worked on your paper?
8. How do you feel about the portfolio so far?
9. What do you think is the strongest part of your portfolio right now?
10. What are some of the weaknesses that you still see in your portfolio or things that you still need to work on? What has been the most difficult part of working on this portfolio?
11. As you were writing, were you thinking about any of the comments that were made in class or workshops or anything that your teacher said from the first portfolio?
12. Who is your audience?
13. How do you actually go about doing research for your papers?
14. Why do your research the way that you do?
15. Have you communicated with your teacher outside of class for any reason? Did you use e-mail, telephone, IM, or any other way?
16. How do you prefer to talk with your teacher? Do you prefer to talk to her in class, out of class, email, telephone?
17. How often would you say you've e-mailed your teacher this semester?
18. Have you ever emailed her a draft to look over and give you comments back on?
19. How comfortable are you with using different types of research, for example, using the databases or the journals or websites?

20. How do you prefer to communicate with the other students—or do you prefer to communicate with the other students in your class? By telephone or email or face to face or any other way?
21. Do you work? How many hours per week? Where?
22. Is there anything else that you've been worried about or is going on as far as family or relationships or?
23. How do you feel physically?
24. What other hobbies or interests do you have as far as what you do for fun or um, in your free time? Or do you not have free time?
25. Do you have any questions for me?

Appendix J - Teacher Questionnaires
Teacher Questionnaire 1

1. What vision/ philosophy/ pedagogical theories influence how you teach writing for this course?
2. What differences do you notice about students' writing in a traditional classroom versus a computer classroom?
3. Which resources do you encourage your students to use to aid their writing?
4. What do you do or teach differently in a computer classroom than in a traditional classroom?
5. What do students seem to like the most about a computer classroom? What do they struggle the most with when they write in the computer classroom?
6. Do you find that there is a difference in the amount of interaction and feedback students receive or initiate in a computer classroom?
7. In what ways have you changed the way you teach writing from a traditional classroom to a computer classroom. Why? Is there anything that you are about to do in the computer classroom that cannot be done in a traditional classroom? Have you noticed if students write differently on the computer as opposed to handwritten class writing periods?
8. How do you teach your students to go through the writing process?
9. What are the best and the worst aspects of computers in the classroom?
10. Did you decide on the classroom arrangement? How would you change it if you could?
11. How do you see the workshops operating during class time? How does it compare to previous classes? How beneficial do you think that workshop periods are?
12. In what ways do you see chaos or complexity theory exhibited in your classroom?
13. Do you have any questions for me?

Teacher Questionnaire 2

1. What changes have you noticed in student motivation since the beginning of the semester?
2. What was your reaction to your students' most recent portfolio assignment for CO 301?
3. How does this classes performance, behavior, and responsiveness compare to previous classes?
4. How does the time of day of the class affect student interactions compared to your other classes?
5. What has gone well in class? What could be improved?
6. What advice do you give your students concerning their writing environment?
7. When will be the next best class periods to observe student writing?
8. What seem to be the biggest concerns for most students concerning their writing?
9. How did students correspond with you outside of class? E-mail? Telephone? IM? Personal conference outside of class? Other ways?
10. Do you have any questions for me?

Teacher Questionnaire 3

1. Is this course a required course for any of the scientific majors or is it an elective credit for most students? (I'm looking at potential motivation for taking the course).
2. Could you elaborate a little more about the rhetorical theory of 301B? What are the epistemic, ontological, teleological, and methodological ideologies that inform your rhetorical theory? Could you elaborate on what models of andragogy you use in your classroom?
3. What were some of the overall impression you had about this past semester's course? How did it compare to past years?
4. Approximately, how many students did you personally meet with to have conferences about their papers? Were there any students who met with you more multiple times before a draft was due or the portfolio was due? If so how many students met with you multiple times and how many times did they meet with you?
5. How do you tend to respond to drafts students give you?
6. What is your grading philosophy for 301? What does it require for a student to get an A, B, C, etc.?
7. What types of questions did they have? Did they have questions about word choice, audience, ethos, pathos, logos, etc.?
8. What sorts of feedback did you get from students about how they perceived the effectiveness in this course for their major?
9. How did students correspond with you outside of class? E-mail? Telephone? IM? Personal conference outside of class? Other ways?
10. What would you have changed about this semester if you could go back and do anything differently?
11. How are you planning on teaching this class differently in the future? What will you keep the same?
12. Did you notice any elements of self-organization in the classroom dynamics? Did any writers help out other classmates to become better writers in any ways that you can remember?
13. As the semester progresses, do you think that students' writing processes become more ordered or chaotic?
14. Do you have any questions for me?

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